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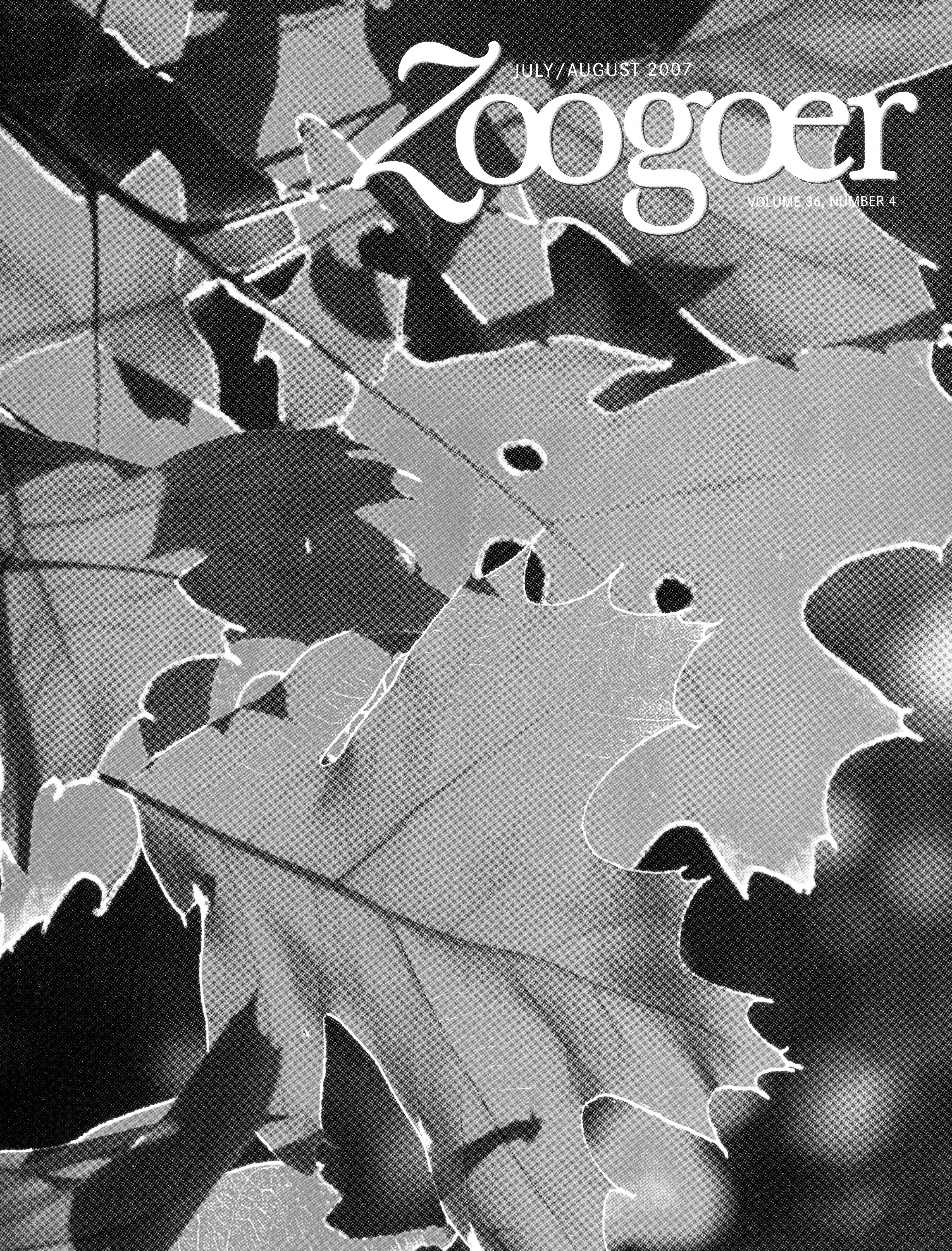

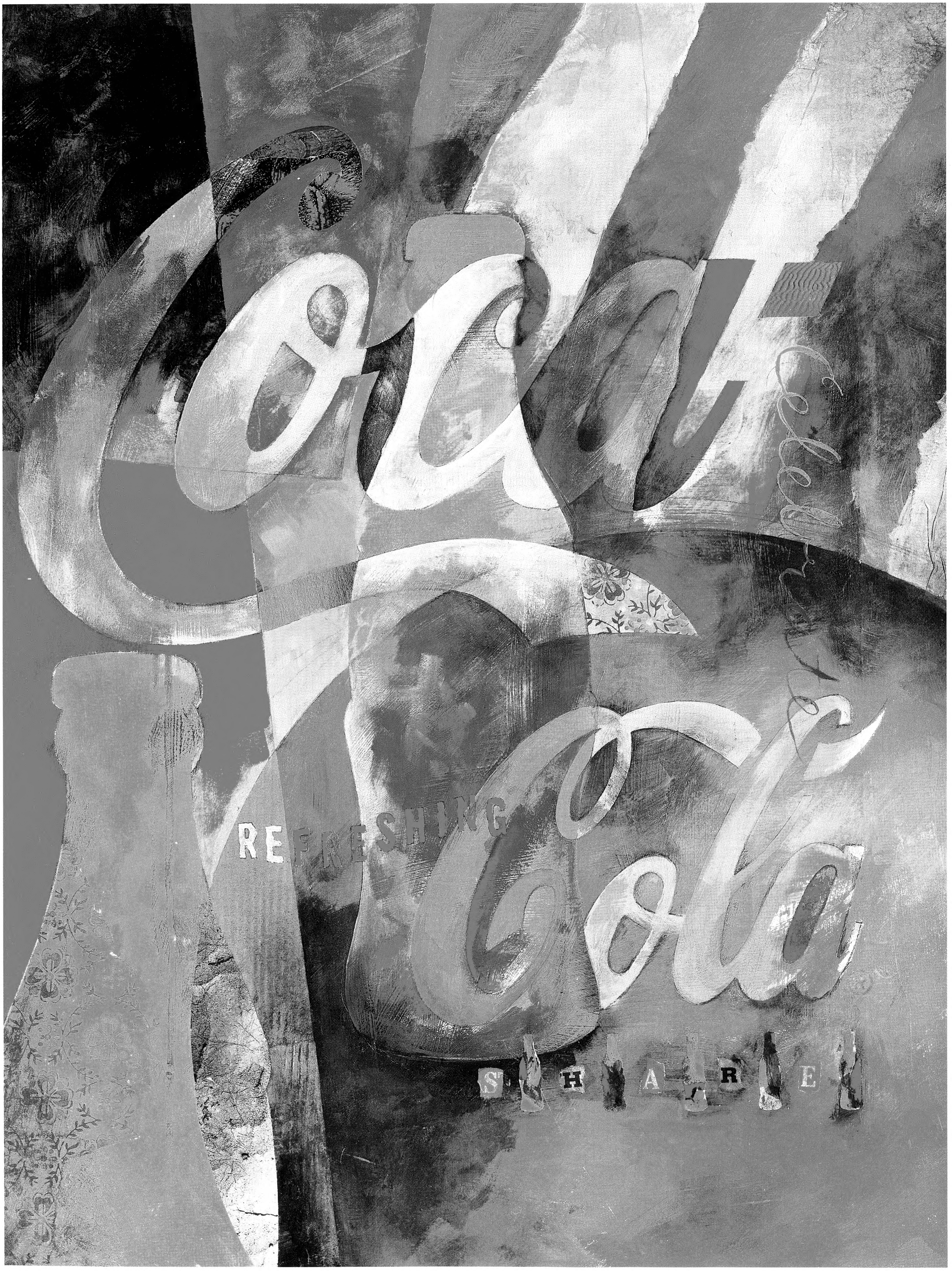
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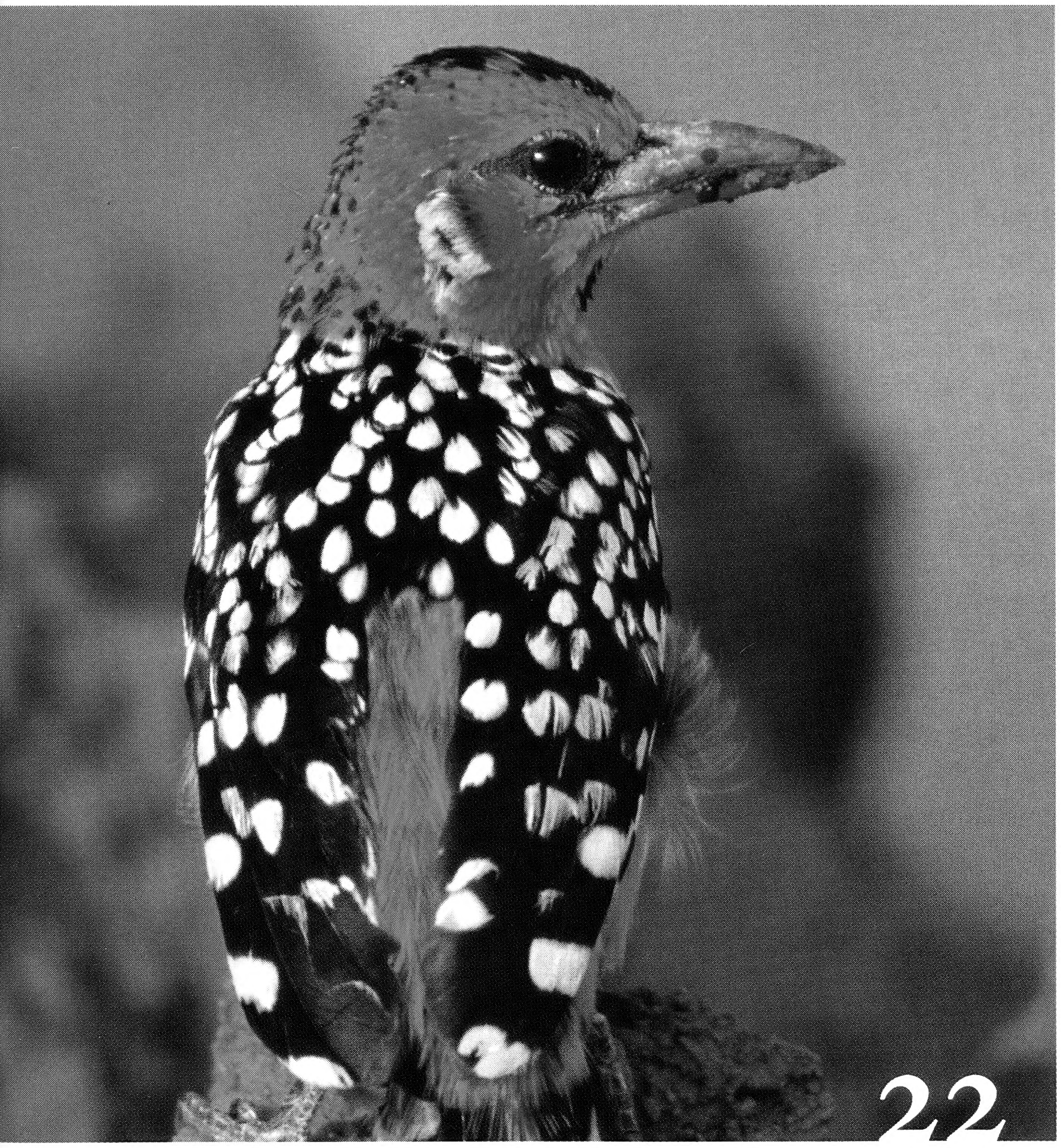
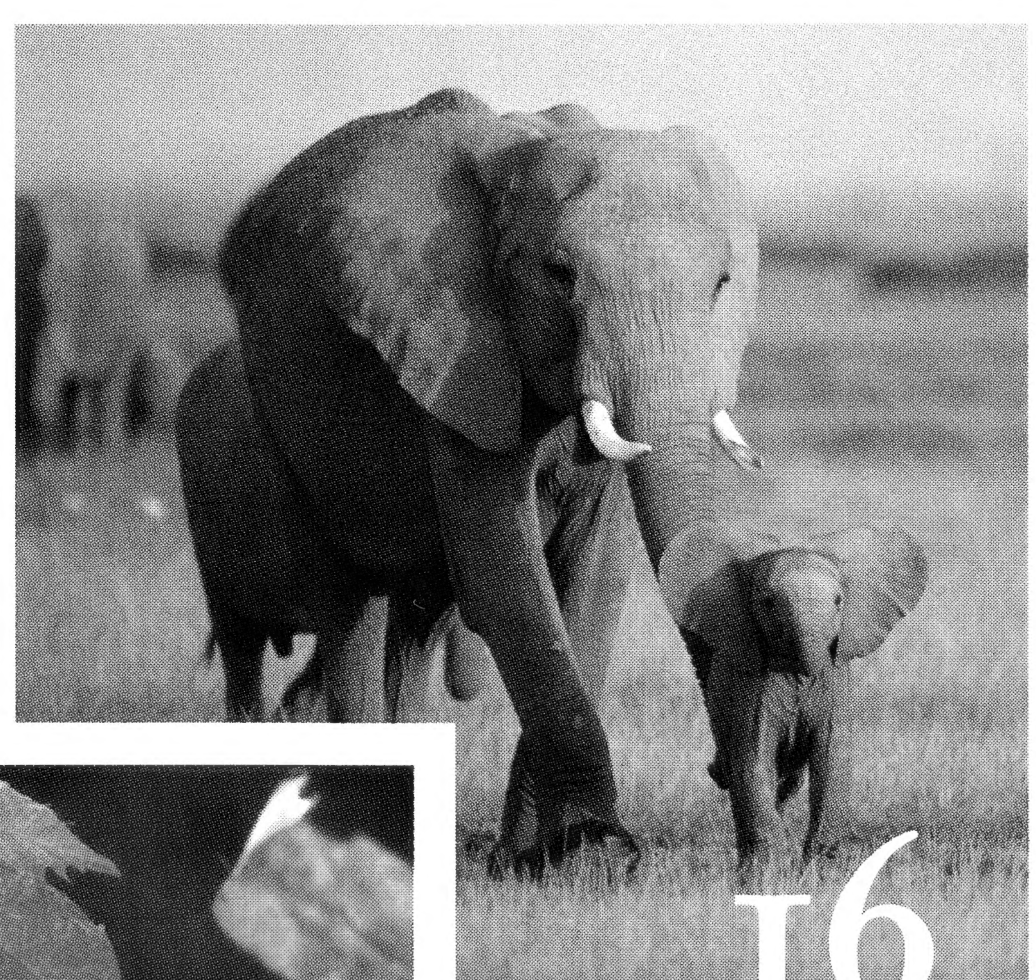
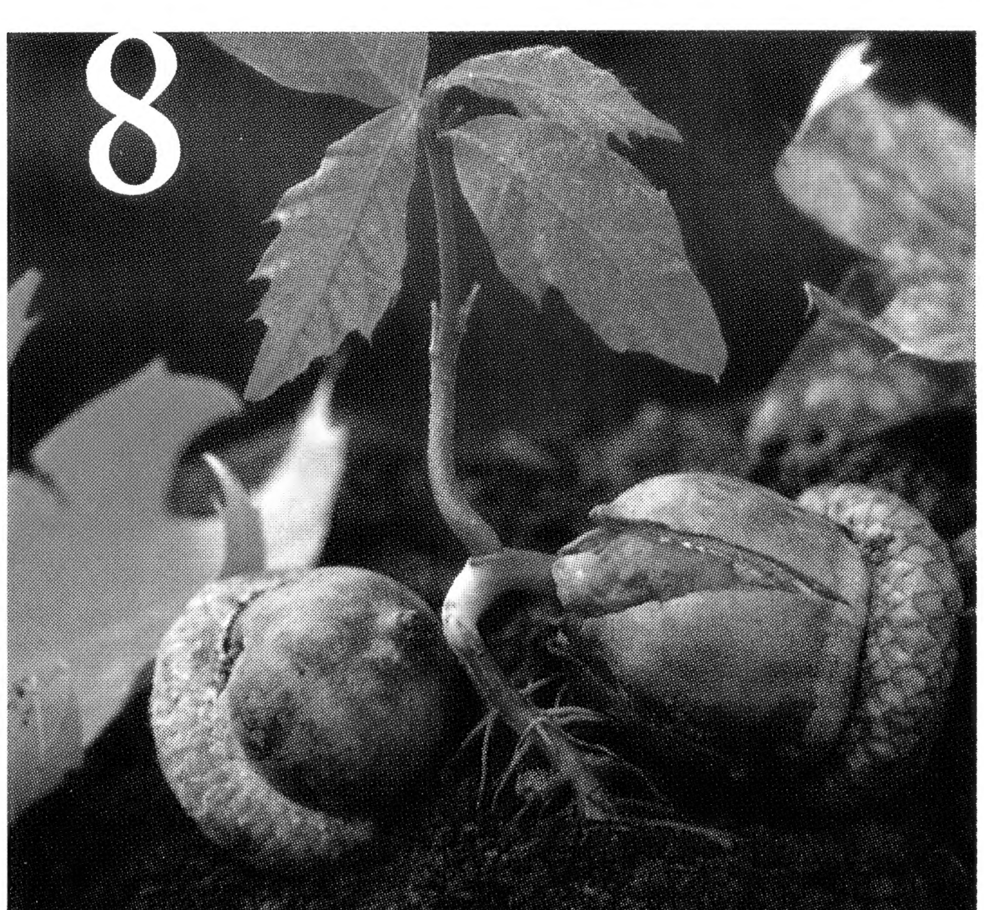
CONTENTS

July/August 2007 | Volume 36, Number 4







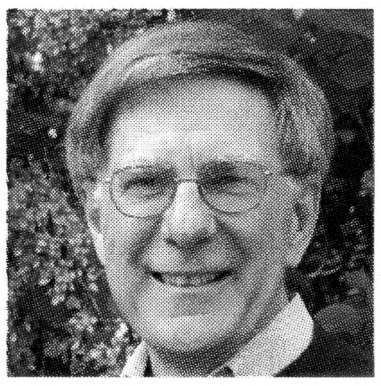
Red-and-yellow barbet: Joe McDonald/Bruce Coleman Inc. African savanna elephants: Bernard Castelein/naturepl.com. Acorns: Dwight Kuhn.

Zoogoer

Features

Departments

Facing Fifty



On April 10, 2008, Friends of the National Zoo will celebrate its 50th birthday. FONZ was founded by a handful of the Smithsonian National Zoo's neighbors as a temporary citizen's group to "do something" about the Zoo's then-deteriorating state. The group quickly accomplished its primary goal: bringing the Zoo's entire federal budget, which had been divided between the District of Columbia's and the Smithsonian Institution's allocations, entirely under the Smithsonian's umbrella. This ensured more consistent support for the Zoo and its scientific research program.

These first members could then have declared victory and disbanded. But they saw many other ways to advance the Zoo's mission and public interest by volunteering their time, creating education programs, promoting interest in the Zoo, and fundraising. Since then, FONZ has grown to include more than 40,000 member families, some 1,500 volunteers, and a full-time staff of more than 100. FONZ is no longer "just" the Zoo's support organization, but integral to the Zoo—neither organization could thrive without the other and both are working toward a common goal of saving wildlife.

So, your Board of Directors decided to review and revise FONZ's mission to reflect that, and to develop a strategic plan to guide our organization into our next half century. With this work now complete, Board President Robyn Kravit and I want to share the new mission and goals FONZ will be working to achieve in the next three years.

Mission: *Friends of the National Zoo is the dedicated partner of the Smithsonian's National Zoological Park. FONZ provides exciting and enriching experiences to connect people with wildlife. Together with the Zoo, FONZ is building a society committed to restoring an endangered natural world.*

Goals: *Provide an Unsurpassed Zoo Visitor Experience.* "Visitor experience" is everything we do to connect people with wildlife, from how much people enjoy their Zoo visit to the depth and diversity of education programs to the quality of our publications and website.

Expand the Partnership Relationship with the National Zoo and Other Partners. FONZ and the Zoo will further integrate our efforts for greater effectiveness in achieving our goals. FONZ will also collaborate with colleagues in other parts of the Smithsonian, and form partnerships with corporate, governmental, and nonprofit organizations that can help us.

Achieve Organizational Excellence and Financial Strength. Everything that FONZ does and how well we can support the Zoo depend on how much money we raise and how efficiently it is spent. We will improve our business practices, especially by investing in staff, upgrading technology and facilities, redoubling fundraising and "friend-raising," and enlisting even more volunteers. The Board is also examining its own structure and governance to ensure these meet the needs of our growing and changing organization.

As always, FONZ's success depends on our members, and Robyn and I welcome your ideas and your participation in all that we do. Please review our strategic plan online at **www.fonz.org/fonzstrategicplan.htm**, and send your comments to FONZPlan@fonz.org. Also, help us plan our 2008 festivities. Send your wild ideas for celebrating our 50th birthday to FONZ50@fonz.org. All of us want 2008 to be a year to remember!

Sincerely,

Bob Lamb

Bob Lamb
Executive Director, Friends of the National Zoo

FONZ Friends of the National Zoo is the dedicated partner of the Smithsonian's National Zoological Park. FONZ provides exciting and enriching experiences to connect people with wildlife. Together with the Zoo, FONZ is building a society committed to restoring an endangered natural world. Formed in 1958, FONZ was one of the first conservation organizations in the nation's capital.

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Smithsonian **National Zoological Park** is located at 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537. Weather permitting, the Zoo is open every day except December 25. Hours: From October 29, 2006, to March 10, 2007, grounds are open from 6 a.m. to 6 p.m.; buildings, 10 a.m. to 4:30 p.m. From March 11, 2007, to November 4, 2007, grounds are open from 6 a.m. to 8 p.m.; buildings, 10 a.m. to 6 p.m.

Membership in FONZ offers many benefits: programs, publications, discounts on shopping and events, free parking, and invitations to special programs and activities to make zoogoing more enjoyable and educational. To join, write FONZ Membership, FONZ, P.O. Box 37012 MRC 5516, Washington, D.C., 20013-7012, call 202.633.3034, or go to www.fonz.org/join.htm.

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An audio version of *ZooGoer* is available on our website, for members who cannot read standard print due to disability. For more information, please visit **www.fonz.org/zoogoer.htm.**

On the cover: Sunlight filters through the leaves of an oak tree. Oaks produce acorns that are a staple food for wildlife. Photo by istockphoto.com/Chad Davis.

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Planning the Finest Future

Even as we've been preparing to break ground on Elephant Trails, the next major step in the Smithsonian National Zoo's revitalization, we've been planning for future revitalization, with the goal of being the world's finest zoo by 2016. In the last year or so, it's been very exciting to try to re-envision the Zoo, not with an eye toward specific new animals or exhibits but toward changing the way visitors, volunteers, and staff experience the Zoo. Now, I invite you to join the process.

We are seeking input—from FONZ members and the entire community—on a proposed master plan for facilities at the National Zoo at Rock Creek. The plan focuses on creating large land areas for new exhibits and making improvements in how we welcome visitors to the Zoo, how visitors move around the park, where they park, and how our staff and volunteers service animal areas.

Up for discussion and input, particularly as they relate to environmental effects on the human and natural environment and on historic properties, are three alternative scenarios for the Zoo's future. One scenario leaves the configuration of the Zoo largely as it is while we continue to make incremental improvements to animal areas, exhibits, visitor services, transportation within the Zoo, and parking availability. The drawback to this option is that it gives us no new land on which to develop expansive new animal habitats, exhibits, and educational experiences.

The other two scenarios plot dramatic, sweeping changes—one, labeled Alternative A, more so than Alternative B. In both, however, large exhibits featuring multiple species would be developed throughout the park, with older exhibits revitalized and expansive new animal habitats and exhibits replacing some of the existing parking lots. Near Kids' Farm, there would be a children's discovery area, and hilly Beaver Valley would be made more accessible from Olmsted Walk, the Zoo's central pathway, via bridges and lifts.

Both plans provide for relieving vehicle congestion on the main road through the Zoo. Both envision a central administrative hub at what is now parking lot C at the mid-point of the Zoo. And both propose revitalizing the major Zoo entrances at Connecticut Avenue and at Rock Creek/Harvard Street with traffic circles to ease congestion.

Alternative B would make the Connecticut Avenue and Rock Creek/Harvard Street entrances the primary entrances to the Zoo (with a smaller entry for visitors arriving by bus), and they would be connected by a bus or tram system running along the road to help visitors move up and down the Zoo's steep hill.

The more dramatic Alternative A proposes a major new entry at parking lot C, with a new parking structure connected to the park by a pedestrian bridge over the road. At the end of the bridge and where the Great Ape House now sits, visitors would find a new entrance pavilion and a grand pedestrian plaza providing information, educational experiences, shops and restaurants, event space, and a tram station. And in the most striking departure, the tram this plan describes is amid the treetops, allowing visitors to explore the importance of our forest canopy. This ski-lift-like system will connect the central station and stations at the Connecticut Avenue and Rock Creek/Harvard Street entrances, and is planned to run only in one direction to minimize impact on the park and our trees. This would be a new way to see and appreciate the Zoo, and to enjoy a new experience focused on the Rock Creek ecosystem where parking lot D is now.

I hope you agree that this all sounds pretty exciting, even though I've sketched here only the broad outlines of these plans for the Zoo's future. I invite you to attend an open house in the Visitor Center auditorium on June 28, from 6:30 to 8:30 p.m., to learn more and provide input on the plans. I also urge you to visit **http://nationalzoo.si.edu/goto/masterplan**, where you can review the plan's details and send us comments by July 31.

The National Zoo belongs to you, and it will only be the world's finest with your support, encouragement, and ideas. I look forward to hearing what you think about these plans to get there.

Sincerely,

John Berry

John Berry
Director, Smithsonian's National Zoological Park

Jessie Cohen/NZP

One of three cheetah brothers that debuted in June at the Smithsonian National Zoo's Cheetah Conservation Station lounges in the shade.

Animal News

Three young male **cheetahs** (*Acinonyx jubatus*) went on exhibit in early June at the Smithsonian National Zoo's Cheetah Conservation Station. Two-year-old brothers Draco, Zabini, and Granger were born at the White Oak Conservation Center in northern Florida and are the offspring of two Namibian cheetahs. The brothers are considered to be genetically valuable, so in the future they will likely be bred with young females under the auspices of an Association of Zoos and Aquariums Species Survival Plan (SSP). In the wild, cheetah brothers typically live together in groups called coalitions, and work together to protect their territory. To maintain their natural social structure, Draco, Zabini, and Granger will live together at the Zoo.

Tiger cubs Maharani, Melati, and Guntur turned one in May.

Jessie Cohen/NZP

At the Great Cats exhibit, the Zoo's three **Sumatran tiger cubs** (*Panthera tigris sumatrae*) turned one year old on May 24. Maharani, Melati, and Guntur—two females and a male—have come a long way in a year. At birth they weighed about two pounds each but by early May the females were about 117 pounds each and Guntur tipped the scales at 150 pounds. In the next few months, the Sumatran tiger SSP will probably recommend that the cubs go to other zoos to find mates, and through their offspring they will help maintain genetic diversity in the zoo population of their tiger subspecies.

Events

For more information on upcoming events at the Zoo, visit **www.fonz.org/events.htm**.

Sunset Serenades

Thursdays from June 28 to August 9–6:30 to 8 p.m.

Enjoy the great outdoors and great music with your family at the Zoo's free summer concerts on Lion/Tiger Hill. Groove to the sounds of jazz, salsa, blues, and rock-and-roll and meet a Zoo animal up close. Bring a snack and picnic on the hillside or purchase refreshments from the Zoo's Mane Restaurant. Visit **www.fonz.org/sunsetserenades.htm** for a concert schedule.

Brew at the Zoo

August 23–6 to 9 p.m

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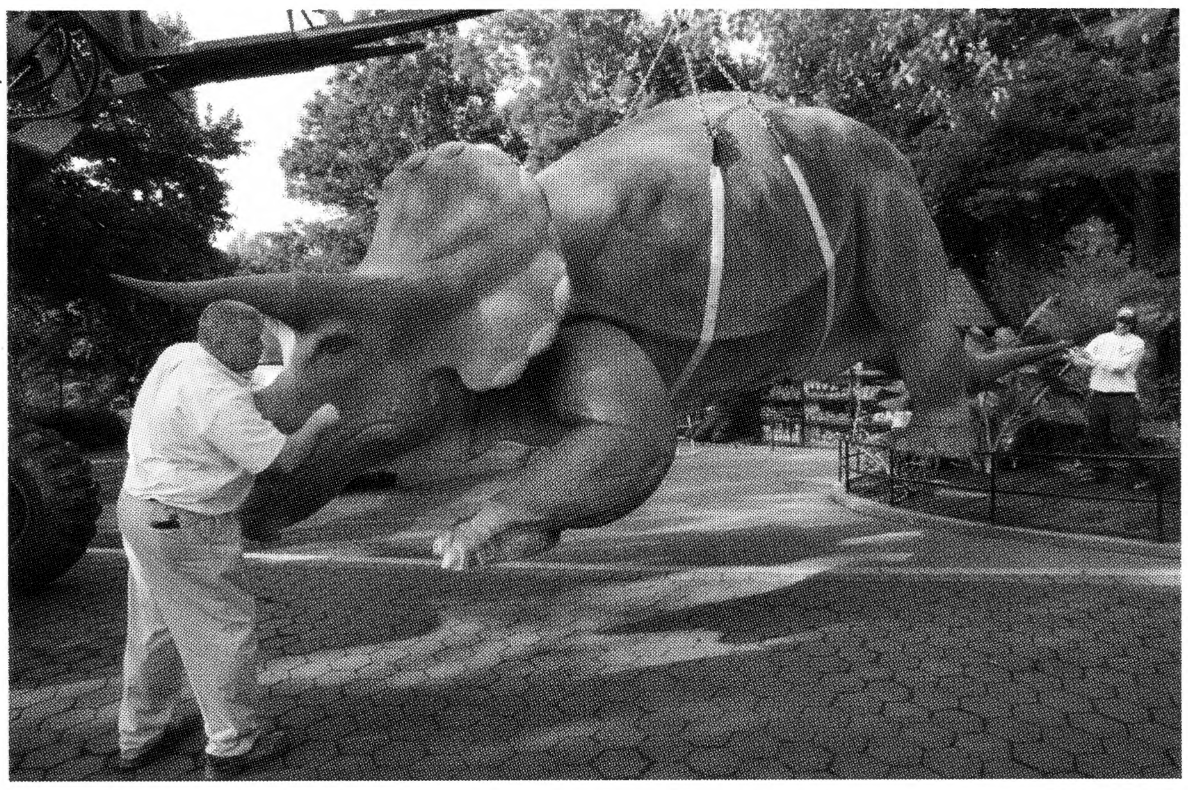
Party like an animal at Brew at the Zoo, FONZ's beer-tasting event for Young Professionals. Sample handcrafted beers from more than 20 microbreweries and hors d'oeuvres from local restaurants, and check out live entertainment. Proceeds benefit a variety of Zoo projects, including Elephant Trails: A Campaign to Save Asian Elephants. Purchase tickets at **www.fonz.org/brew.htm**.

Zoo Happenings

Jessie Cohen/NZP



Moving Uncle Beazley to a garden exhibit.

The Zoo's lemurs have a new neighbor: a life-size triceratops statue named Uncle Beazley. Designed by Louis Paul Jonas, the statue appeared in a television movie based on the 1965 children's book *The Enormous Egg*, by Oliver Butterworth, about a boy who finds an egg from which a triceratops hatches. The boy names his new friend Uncle Beazley, and when it grows too large to stay at his house he takes it to the Smithsonian; eventually, the dinosaur is sent to live at the Zoo's Elephant House. The Uncle Beazley fiberglass statue was donated to the Smithsonian in 1967 and was most recently displayed in the Zoo's former rhino area, but was removed to make room for the Zoo's expanding Asian elephant habitat. The Zoo recently restored it, and it is now on display next to Lemur Island in a garden of plants such as ferns and papyrus, whose ancestors lived in the age of dinosaurs.

Wondering what animals live in your backyard, and how you can make it more wildlife friendly? Find out at the new Zoo in Your Backyard exhibit, just off Olmsted Walk near the Panda Cafe. The exhibit's yard area is a study site for the Migratory Bird Center's Neighborhood Nestwatch, a research program in which area citizens act as "backyard biologists" who help Zoo scientists monitor local bird nests. A small pond provides habitat for insects, amphibians, and birds, and you may see hummingbirds feeding in the flower garden. Displays identify common backyard animals, and signs give tips on attracting wildlife to your own backyard.

Volunteer Corner

Caroline Winslow

FONZ employee and horticulture volunteer Lee Hanley in the Zoo's greenhouse.

Lee Hanley is a very busy woman. Not only is she an administrative assistant in FONZ's Department of Education, Events, and Volunteer Services, but she also has volunteered in the Zoo's horticulture program for 23 years. With all the hours she spends at the Zoo, it seems like she wouldn't have time for much else. That couldn't be further from the truth. Her career and hobbies are as varied as the plants in the greenhouse where she volunteers.

Before Lee came to the Zoo, she worked for Smithsonian museum shops and several Smithsonian Visitor Information Centers on the Mall. "I think I hold a record," she adds, for working in every existing Smithsonian museum shop. She remembers fondly her encounters with celebrities at the Hirshhorn Museum and Sculpture Garden, including Margaret Hamilton, who played the Wicked Witch of the West in *The Wizard of Oz*, and *Green Acres'* Eddie Albert.

When she's not at the Zoo, Lee indulges her passion for needlepoint, a craft she has enjoyed as long as she can remember. Years ago, she created samples for books her mother wrote on the subject. Now, she creates them for a needlepoint shop in Washington, D.C., where she also works part-time.

On top of all of this, she volunteers for public broadcasting network WETA's fundraising and special events, which she says are "always different and always fun." Much like her life.

—Molly Woods

Dwight Kuhn

More than 50 species of oak grow in the United States, and their acorns provide essential nourishment to wildlife. But if numbers of young oak trees continue to decline in U.S. forests, acorns may become scarce.

acorns:

MASTERS OF THE FOREST

by Mary-Russell Roberson

Consider the acorn. Compared with other seeds found in the forest, it's big, tasty, and nutritious. Because it has a hard cover, it can survive on the forest floor or in a hidden cache for months without rotting. It is up to 25 percent fat and, with the exception of the cap and the outer covering, easily digested by most animals. In a good year, hundreds of thousands of acorns can rain down on an acre of oak forest in the eastern United States.

Is it any wonder that acorns are the most important food source for animals in the eastern deciduous forest?

Oaks (*Quercus* spp.) are the only abundant and widespread trees in North America that produce such useful seeds. American chestnuts (*Castanea dentata*) were once as plentiful as oaks, and produced a nut that was valuable to humans and wildlife. Unfortunately, virtually every mature chestnut in North America was killed between 1920 and 1950 by a fungus (*Cryphonectria parasitica*) introduced from Asia. Beech trees (*Fagus grandifolia*) produce nutritious nuts, but are diminishing due to an introduced beetle and fungus. The nuts of hickory trees (*Carya* spp.) are too tough to be useful to any animals save sharp-toothed rodents and bears. North American wildlife that evolved to eat acorns, chestnuts, and beechnuts now rely primarily on acorns.

Rick Ostfeld

Annual acorn production varies, depending on the cycles of individual oak species and the weather. In abundant years, rodent numbers surge; when the acorns are gone, the rodents eat the eggs of ground-nesting birds.

Fossil pollen records indicate that oak forests have flourished in North America for about 10,000 years. Today oaks are common everywhere except some areas in the northern Rocky Mountain states. More than 50 species live in the United States, and diversity increases southward; Mexico is home to more than 100 species of oak.

Unfortunately, our oak forests are in trouble. Although mature oaks still dominate many forests, the percentage of young oaks in the understory is declining rapidly. According to the Forest Inventory and Analysis program of the U.S. Department of Agriculture's Forest Service, the percentage of oaks in the understory declined from 32 percent to 21 percent from 1989 to 2000. Although acorns are plentiful in forests today, wildlife biologists and foresters are concerned they might not be so abundant in the future.

"If we want large wildlife populations, we need to have a hard seed crop," says Bill McShea, a research scientist in the Smithsonian National Zoo's Center for Species Conservation. "Acorns are an essential food for them in the winter."

Although acorns are plentiful in forests today, wildlife biologists and foresters are concerned they might not be so abundant in the future.

Dozens of species of birds and mammals in eastern forests depend on acorns, including black bear, white-tailed deer, white-footed deermouse, squirrel, turkey, blue jay, red-headed woodpecker, and ruffed grouse. The health of these and other animal populations is tied to the number of acorns produced each year.

Oaks are "masting" trees, meaning that in some years they produce prodigious amounts of seed and in others, they produce virtually none. The abundant years are called "mast" years, or "good mast" years. Oaks of one species in a localized area are often synchronized, producing many or few acorns in lockstep. Scientists haven't worked out exactly how this happens, but in many cases, weather plays a role. For example, a late frost might kill the flowers on all the oaks of a particular species in a particular area. (Chestnuts produced seeds more regularly, partly because they flowered in June, after the threat of frost had passed.)

In forests with more than one oak species, the number of acorns varies from year to year; some species take one year to go from flower to acorn while others take two, and each species produces a different amount of acorns. The effect of weather on acorn production

also varies with each species. But every so often, most or all of the oak species in an area produce either a bumper crop or a paltry crop at the same time. The effect of all this variation on wildlife is significant.

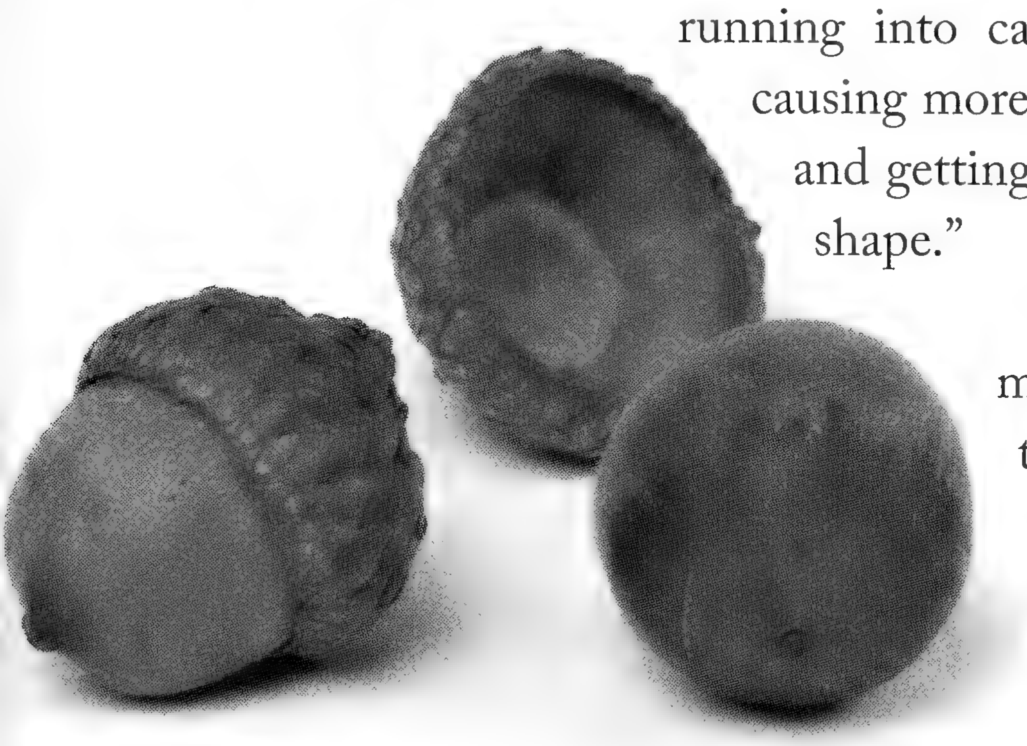
Take black bears, for example. In Great Smoky Mountains National Park in North Carolina and Tennessee, and in Shenandoah National Park in Virginia, acorns are the bears' most important fall food. Before spending the winter sleeping and fasting in dens, which are often in big old oak trees, the bears fatten up on acorns. Females give birth in these winter dens, and if the acorns are abundant in the fall, they gain more weight and are more likely to produce cubs that survive. In years of few acorns, females either fail to give birth, or their cubs die soon after birth.

In mountainous areas that are not protected within national parks, bears have a more varied diet that includes berries and fruit trees, which are less common in deep forest habitats, and food from human sources such as garbage and agricultural crops. However, these bears' reproductive success is still tied to acorns, according to Gordon Warburton, a supervising wildlife biologist with the North Carolina Wildlife Resources Commission who studies bears in the mountains of western North Carolina. "We do see an increased failure rate in reproduction even outside the park in poor mast years," he says.

Because black bears are omnivorous, not all populations depend as heavily on acorns. Those living in the coastal plain of North Carolina, for example, fatten up in the summer and fall on crops such as corn, while those that live in coastal Virginia primarily eat inkberries (*Ilex glabra*). But for those living in oak forests, acorns are so crucial that they can cause synchrony in bear cub production. "During a bad mast year, nobody reproduces. In a good year, everybody reproduces," says Warburton.

Acorn production also strongly influences movement—and mortality—of adult bears. When an abundant acorn crop falls on the forest floor, bears don't cover large territories, because they don't have to. "It's like a big buffet," Warburton says. Because they aren't traveling, bears aren't as likely to get hit by cars, wander into people's backyards, or be spotted by hunters. They are eating more and exercising less than usual, so they go into their dens with plenty of fat and come out in spring with fat reserves to spare.

"The complete opposite occurs during a bad year," Warburton says. "Bears are traveling more and burning more energy. They are running into cars and getting hurt; causing more nuisance complaints; and getting into the den in poor shape."



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Acorns influence movements of white-tailed deer as well, but in a different way. During the autumn of a good mast year

Pat & Chuck Blackley

A black bear forages for acorns in Great Smoky Mountains National Park.

deer spend more time in oak forests, according to McShea. During the autumn of a bad mast year, deer are more likely to inhabit other types of forests—maple forests, for example—where they may eat small plants and seeds.

Many rodents eat acorns, and because they have short life cycles, they are particularly responsive to variations in acorn abundance. "The number of mice and chipmunks and squirrels you have one year is a function of how many acorns you had the previous fall," says McShea. Long-term studies in Virginia, Maine, New Zealand, and Europe have repeatedly shown this relationship, with various species of seed-producing trees and rodents. In eastern forests in the United States, it occurs between the white-footed deermouse (*Peromyscus leucopus*) and oak trees. In years with many acorns, white-footed deermice begin breeding about a month earlier than in other years, which allows them to produce more offspring.

Rodents play important roles as both prey and predators in the lives of many other forest animals, so acorn abundance has wide-ranging ramifications in the forest ecosystem. For example, a good mast year is bad for ground-nesting birds such as the ovenbird (*Seiurus aurocapillus*), wood thrush (*Hylocichla mustelina*), and veery (*Catharus fuscescens*). Populations of white-footed deermice and eastern chipmunks (*Tamias striatus*) boom when acorns are plentiful, but by late spring, the acorns are long gone and the multitudes of rodents are hungry. "That's when they attack the eggs," says Rick Ostfeld, senior scientist at the Institute of Ecosystem Studies in Millbrook, New York. "When there are a lot of rodents, the nesting success of these ground-nesting birds is very low, so the following year bird abundance is low." Ostfeld and his colleagues have demonstrated this relationship in New York, and McShea and his colleagues have demonstrated it in Virginia.

Intriguingly, a poor mast year is also bad for ground-nesting birds. "When there are very few rodents in the system, we find the birds' nesting success is high, but there are about equally few birds the following year as when there are lots of mice," Ostfeld says. While he and his colleagues don't have direct evidence of the mechanism, he says, they believe that raptors such as hawks and owls eat more birds—both fledglings and adults—when they have

Scott Bauer/ARS

In a lifetime, adult female black-legged ticks can lay up to 3,000 eggs; those that hatch and survive to become nymphs can transmit Lyme disease.

a hard time finding rodents. "It's sort of the Goldilocks effect," he says. "The number of acorns or mice has to be just right."

White-footed deermice are players in another interesting ecological web, this one involving gypsy moths (*Lymantria dispar*) and acorns. Gypsy moths, which are native to Europe, arrived in Boston in 1868. Ever since, they have been spreading southward (to the Carolinas) and westward (to Wisconsin), but slowly, because female gypsy moths cannot fly. Their populations fluctuate quite a bit: Years of low to moderate populations are occasionally punctuated by a dramatic population increase, or "outbreak," lasting two or three years. During outbreaks, the moths can defoliate large tracts of forest, drastically decreasing acorn production in the area.

While variations in gypsy moth populations are most likely caused by the interplay between several factors, white-footed deermice do play a role. Ostfeld and other ecologists have found that white-footed deermice are the main predators of gypsy moth pupae, which can be found in the summer on the forest floor or low to the ground on tree trunks. In natural areas where white-footed deermice were experimentally removed and kept out with barriers, many more pupae survived, and there were 35 times as many gypsy moth egg masses the following year as compared with similar control plots that contained mice. (Ostfeld had to hire extra field assistants to help destroy the egg masses so as not to cause a localized gypsy moth outbreak.) Ostfeld believes that in years of average to high mouse density, the mice keep the gypsy moths in check. In years with few acorns and few mice, gypsy moths experience rapid population growth. In theory, a positive cycle may exist in which more gypsy moths leads to more defoliated oaks, which leads to fewer acorns, which in turn leads to fewer mice and more gypsy moths, and so on. But this loop has not been quantitatively observed and recorded.

Ostfeld also studies an ecological system involving acorns, mice, deer, ticks, and Lyme disease. People contract Lyme disease when they are bitten by a tick infected with the bacterium *Borrelia burgdorferi*. In the northeastern United States, and as far south as the Carolinas, that tick is likely to be the black-legged tick (*Ixodes scapularis*), which has four stages in its two-year life cycle: egg, larva, nymph, and adult. When eggs hatch in the spring or summer, the larvae emerge without the bacterium, but if they acquire it as larvae, they can pass it on as nymphs or adults.

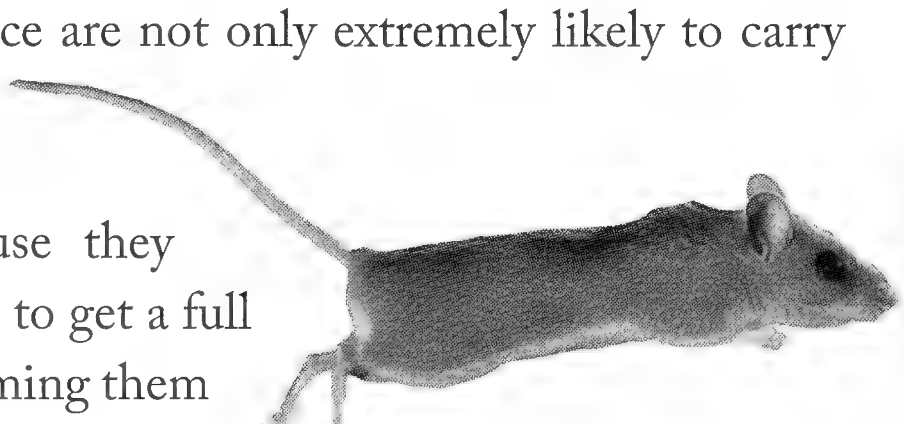
Tick larvae feed on a variety of vertebrates including lizards, birds, and mammals. A larva needs only one blood meal, which takes two to three days to consume. Afterward, it falls to the ground and molts into a nymph. The following spring or summer, the nymph becomes active and takes one blood meal from any of a wide variety of hosts, then molts into an adult tick. In the autumn of the same year, the adult takes one three- to four-day meal. The host is usually a white-tailed deer, but may also be another mammal such as a raccoon, coyote, or human. After feeding, the tick falls to the ground. Female ticks lay eggs the following spring before dying.

People usually get Lyme disease from nymphs rather than from larvae or adults, because larvae rarely carry the bacterium and adults prefer to feed on deer. Furthermore, adult ticks are larger (2 to 3 mm) than nymphs (1 mm) and therefore more likely to be spotted and removed by humans before the infection is transmitted.

Ostfeld and his colleagues tested various animals in forested areas of New York to determine which ones were carrying the Lyme disease bacterium and passing it on to tick larvae. They found that 92 percent of tick larvae that fed on wild-caught white-footed deermice became infected with the bacterium. That means the white-footed deermouse is a good reservoir species—it carries the bacterium without showing negative symptoms—of Lyme disease. In comparison, slightly more than half of larvae that fed on wild-caught chipmunks became infected, 15 percent of larvae that fed on squirrels became infected, and only about three percent of larvae that fed on opossums became infected.

White-footed deermice are not only extremely likely to carry the Lyme disease bacterium; they are also "permissive" hosts because they typically allow tick larvae to get a full blood meal without grooming them

Rolf Nussbaumer/naturepl.com



White-footed mouse.

Joe McDonald

Although white-tailed deer rarely transmit the Lyme disease bacterium to ticks, they do transport ticks to sites with large populations of one of the disease's main carriers—white-footed deermice—when foraging for acorns.

off. There are so many mice in a typical forest that collectively, they host as many tick larvae, if not more, than other species, even those that host more larvae per individual. Ostfeld found that the average white-footed deermouse carries 29 tick larvae, the average chipmunk 36, the average squirrel 142, and the average opossum 254. Based on the field work of Ostfeld and his colleagues, then, the most common way people get Lyme disease (at least in the forests of New York) is by serving as a host for a nymph that fed on an infected white-footed deermouse as a larva the previous summer.

Biodiversity among animals in eastern deciduous forests depends on oak trees and acorns.

Contrary to popular belief, deer very rarely transmit the Lyme disease bacterium to ticks. When it was first discovered in the 1970s, scientists studied the ecology of Lyme disease on islands in Long Island Sound. They found what they thought was a new species of tick, and because they observed it feeding mostly on deer, they called it the deer tick. Later that tick was identified as a northern population of the black-legged tick, but the colloquial term "deer tick" had already caught on. Furthermore, the ecological relationships on the islands were not typical elsewhere. "When studied in mainland sites," Ostfeld says, "things were a lot more complicated and adult ticks were not associated exclusively with deer. It shouldn't be called a deer tick."

Deer do, however, play a role in transporting black-legged ticks. Ticks can't cover much ground on their own; they go where their hosts go. And where deer go is strongly influenced by acorns.

In an autumn of acorn abundance, deer spend more time in oak forests, bringing adult ticks with them. Tick eggs hatch the following spring into a forest filled with large populations of white-footed deermice produced by the previous fall's acorns. A high proportion of the larvae feed on the mice and become infected with the Lyme disease bacterium; the following summer, as nymphs, they infect more mice, people, and other vertebrates. In other words, the risk of contracting Lyme disease in and around oak forests in the northeastern United States is higher two summers after a bumper crop of acorns.

Ostfeld and his colleagues confirmed this in a study published in the journal *Ecological Applications* in 2005. "What we found for Dutchess County [New York]—and this extended over to Connecticut as well—was an association between the actual per capita incidence of Lyme disease and acorn production two falls previous or the mouse population one summer previous," Ostfeld says.

There is also a connection between the presence of white-tailed deer and the occurrence of Lyme disease, but it's not a one-to-one relationship. "There's some low threshold of deer abundance that you need to get a burgeoning tick population, but once you've exceeded that any increase in deer abundance has little effect on ticks," Ostfeld says. "A single deer can feed hundreds to thousands of ticks in a given season." An intriguing study published in the journal *Ecology* in 2006 indicates that excluding deer from areas smaller than five acres does not decrease the number of ticks in that area, and may in fact increase it.

What's probably more important than the size of the deer population in controlling Lyme disease is the overall biodiversity of the area. Mice are generalists that can flourish in all kinds of habitats, whether degraded or relatively undisturbed. In degraded habitats without much biodiversity, there are many mice and few other species. "In a high-diversity community you have fewer mice and more other hosts," Ostfeld says, "and every one of the other hosts is a less competent reservoir for the bacterium." Other hosts are more likely to remove and kill tick larvae that try to feed on them. "Diversity plays a protective role in enticing ticks away from mice," Ostfeld says. There is also some evidence that West Nile virus and hanta virus are more easily transferred to humans in areas of low biodiversity.

Biodiversity among animals in eastern deciduous forests depends on oak trees and acorns. The Forest Inventory Analysis shows that maples (*Acer* spp.) are increasing in abundance while oaks are declining. "Maples are not producing seeds that are useful for very many things at all," McShea says.

For the past 10,000 years or so, the forests of America have for the most part been made up of the same species that we see today, but in varying combinations and proportions depending on changes in climate and other ecological factors. For various reasons, conditions today favor maple over oak.

Oaks don't require full sun, but neither do they prosper in full shade. Bill Healy, a retired research wildlife biologist with the U.S. Forest Service in Amherst, Massachusetts, says, "Because acorns are such big seeds, they can germinate in low light levels and live for a year or two, but to make a positive growth they need 50 to 75 percent light, so they need a stand that is pretty open and that has been disturbed." That "disturbance" can be caused by fire, tornadoes, hurricanes, ice storms, insect infestation, or even selective and targeted logging.

Blue jays stash acorns in their fall larders, inadvertently acting as oak seed dispersers.


Marie Read

Frans Lanting/lanting.com

Oaks are common in most of North America. These California live oaks (*Quercus agrifolia*) grow near Monterey Bay, California.

Native Americans used fire purposefully and regularly to open up forests for hunting, agriculture, travel, and to encourage growth of plants they found useful. Forest fires give oaks several advantages over other trees. Big old oak trees, for example, have thick bark that can often ward off a small fire's damage. Even if an oak dies back, it sends up new sprouts. Unlike maple seedlings, oak seedlings can resprout after a fire because they have a more developed root system. And repeated fires make for a sunnier, drier, more open forest, which suits oaks better than other trees.

Due to years of fire suppression, most of today's forests contain relatively dense understories of brush and young trees. Maples and yellow poplars (*Liriodendron tulipifera*) can sprout and grow in these conditions, but oaks are not as successful in the deep shade.

Fire suppression is not the only challenge facing oaks. They are also being hurt by browsing of seedlings by deer, defoliation by gypsy moths, logging for timber, acid precipitation, urban and suburban development, oak wilt (caused by the fungus *Ceratocystis fagacearum*), and sudden oak death (caused by the pathogen *Phytophthora ramorum*).

McShea says, "Maybe we're talking about oaks declining a few percentage [points] a year. We're not at a critical stage, but because things take so long…in forestry, and because oaks take 30 to 40 years to produce their first acorn, if you want to turn things around you've got to start now." McShea, Healy, and many other foresters and wildlife biologists are recommending that oak forests be managed to encourage new oak growth, which might involve prescribed burns and selected cutting. "The idea of putting a fence around this and letting nature take its course isn't going to work for oaks," McShea says. "It's going to take active management."

Before Native Americans began burning forests, natural fires and periods of warmer, drier weather allowed oaks to survive. But paleoecological evidence suggests that oak forest really began to prosper and spread between 5,000 and 7,000 years ago, when Native Americans began burning regularly.

"This world here in the East is manmade," McShea says. "We made the forests where the forests are. We made the fields where the fields are. We've gotten rid of so many species already—the passenger pigeon, American chestnut, wolves, bison. What's left is something that is a managed world."

Healy says that although the composition of America's forests has fluctuated naturally for thousands of years, what's going on now is different because the chestnut is gone and the beech is fading. "Why worry about the change?" he asks. "If the oak forest goes to maple and birch and yellow poplar, why does it matter? It matters because the wildlife that we enjoy in eastern forests, that whole vast community, is dependent on hard tree seeds, and that's been true for 10,000 years." Z

—Mary-Russell Roberson is a contributing editor to ZooGoer.

A female African savanna elephant and her calf lead a herd in Amboseli National Park in Kenya. Genetic studies are enhancing scientists' understanding of this species' familial relationships.

The Social Lives of Savanna Elephants

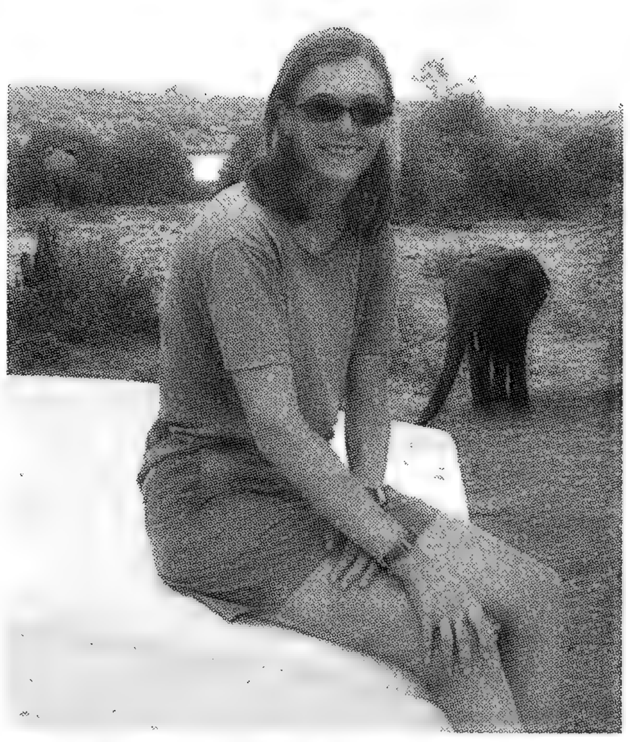
by Jeffrey P. Cohn

Elizabeth Archie sat in her beat-up four-by-four among the tall grasses in Amboseli National Park in southern Kenya, watching and waiting. After what seemed like forever, the elephants she had been observing finally ambled off toward some trees along the savanna's edge. That was the moment Archie was waiting for. Like a woman possessed, she leaped out of the vehicle, dashed over to where the elephants had been grazing, and donned a pair of latex gloves. Then she reached down and picked up a handful of elephant dung, shoved as much of it as she could into a plastic tube, added some ethanol to remove the water, and shook the resulting glop.

Decades of observational research have shown that African savanna elephants establish strong social ties within their own herds and even with elephants in other herds. Genetic studies are illuminating patterns in these relationships.

Archie, a postdoctoral fellow at the Smithsonian National Zoo's Center for Conservation and Evolutionary Genetics (CCEG), is into elephant dung in a big way. Since 1995, she has filled hundreds of plastic tubes with it. Her goal was not to discover what the elephants eat or which hormones course through their bodies, as it is for most field biologists who collect dung. Rather, she sought to learn which elephants are related to which others, the degree to which different elephants are related, and how that determines their interactions.

For decades, noted elephant experts Cynthia Moss, Iain Douglas-Hamilton, Joyce Poole, and other scientists have used field observations to collect data on the social structure of elephants living in savannas and woodlands of eastern Africa. While the classification of African elephants is still somewhat controversial, many scientists believe these African savanna elephants belong to a separate species—*Loxodonta africana*—than African forest elephants (*Loxodonta cyclotis*), which live in the continent's western forests. Because African forest elephants' populations are smaller and they are more difficult to observe in their forested habitat, much less is known about their social and genetic relationships, although National Zoo scientists are working to change that.



Elizabeth Archie.

At Amboseli, scientists have documented or estimated the birth dates of all elephants born at the park since 1972. From these and other studies, they have learned that African savanna elephants live in family groups of up to 20 adult females and their juvenile offspring. In all, elephant groups may number up to 40 individuals. Daughters tend to stay in the family or core group they were born into, but males usually leave the group when they become teenagers. They may hang out with other males on the outskirts of the family groups, typically joining the females only to mate.

Such information based on observational field studies has long formed the basis of most of what we know of species' behavioral ecology. But observational studies may not always be useful in determining relatedness among elephants or other animals. Scientists may miss seeing a male and female mating, for example, especially if it occurs at night. Thus, they cannot be sure which male fathered a female's offspring. Or they may not know whether or how a new female joining a family group is related to the group's members. And they have no way of knowing for sure how individual elephants born at Amboseli before 1972 are related.

Archie's studies have helped fill in those and other blanks. She extracted mitochondrial DNA, which is inherited exclusively through one's mother, to look at deep maternal relationships.

She also analyzed repeating sequences of nuclear DNA called microsatellites to find out which ones in individual elephants were the same or similar to those in other elephants.

Traditionally, scientists conducting genetic studies of wild animals extracted DNA from either blood or tissue. But obtaining these samples from wild animals, especially elephants, is difficult and dangerous. Dung, on the other hand, is easy to collect and does not necessitate tranquilization. Because heat, humidity, and sunlight degrade DNA in dung, Archie had to collect a lot of samples to get enough DNA to carry out her tests.

In so doing, Archie added a new twist to what we know about African savanna elephants. She found that nearly all wild elephants living in family groups whose dung she tested are closely related. That finding corroborates what other researchers have observed in 35 years of field studies at Amboseli and elsewhere in Africa. It also helps further our knowledge of why certain animals choose to live in groups, how group living benefits both the society and individuals within it, and what forces keep individual members within a group. Moreover, Archie's work has demonstrated how the study of genetics can bring new insights to wildlife biology and help promote conservation.

Archie's DNA studies were the first to use genetics as a way of examining how kinship affects social relationships among wild African elephants.

Archie's DNA studies were the first to use genetics as a way of examining how kinship affects social relationships among wild African elephants. "Our studies have shown what an elephant group should look like," Archie says. "Until now, elephant social groups have been defined [by field scientists] based on their behavior. Our study shows they are also genetic units. The most important social relationship is that between close relatives [mothers and daughters, sisters, aunts and nieces, and first cousins]. Such relatives may cooperate in raising calves, defending against predators, and finding food and water."

"Beth has enabled us to better understand the natural world of the African elephant," says Robert Fleischer, head of the CCEG. "We're using genetics to learn more about the social and mating systems of elephants. That may help us better manage and conserve elephants both in the wild and in zoos."

Archie's studies are of particular relevance now because African elephants are facing a crisis. Under assault by poachers seeking their ivory tusks in some areas of Africa and culled because they are overpopulating others, the total estimated number of wild savanna and forest elephants has dropped from 1.3 million in 1971 to between 300,000 and 500,000 today. Despite the fact that it is illegal, some 23,000 elephants were killed in Africa for their tusks in 2006. Kenya alone saw its population of savanna elephants plummet by 85 percent from 1972 to 1989. Asian elephants (*Elephas maximus*) are also declining: Only about 30,000 to 50,000 remain in the wild due to habitat loss.

Scientists have long known that the adult females in a family core group are usually sisters, the mothers or aunts of the youngsters in the group, or the grown daughters of the adult females. They have also learned that several family groups living in the same area may come together from time to time to form what scientists call bond groups. Several bond groups living in the same general area constitute an association.

Elephant societies are known to be very flexible, with a fluidity akin to those of humans. Individual elephants frequently change which other elephants they associate with. Some core groups are very cohesive and remain together for long periods of time, while others are looser and may divide often. When elephant groups divide, usually temporarily, the members split into smaller subgroups. Those subgroups may come back together to re-form the family group later that day or the next, but sometimes stay apart for weeks. Other times they may even join another core group, but usually return to their original family group.

When family groups divide, the adult females remain with their close relatives. When core family groups fuse with other core groups in a bond group, it is because the oldest females in the different family groups are closely related. The link between these maternally related core groups can persist for decades, long after the original female kin have died.

The family and bond groups as well as the associations practice what Archie and other scientists call fission-fusion, denoting a social structure in which elephant groups divide and reunite frequently, often in the space of a few hours or days. Individual elephants may leave their family group and mingle with individuals in another, then return to their own group. Core groups may come

Peter Blackwell/naturepl.com

Peter Blackwell/naturepl.com

Two young African savanna elephants bond in Amboseli National Park.

together during the wet season in Africa, when food and water are plentiful, then break up again when resources are scarce during the dry months. Although core group fissions are usually temporary and the subgroups later fuse, sometimes fissions are permanent. Core groups have broken up and not come back together a half dozen times or so at Amboseli since 1972, Archie says.

Scientists have also noted that dominance within elephant family groups is based on age and size, Archie says, not nepotism. That distinguishes elephant groups from those of many primates. Among the latter, the offspring of dominant females often get preferred access to food and mates, as well as a leg up in the social hierarchy. Young female elephants, on the other hand, have to wait for such advantages until the older matriarchs die and they become the oldest and largest females in their group.

Archie's studies showed that relatedness and genetic patterns overlay social groups among African elephants, says Susan Alberts, an associate professor of biology at Duke University in Durham, North Carolina, who oversaw Archie's doctoral dissertation. "Elephants do not associate by random. They seek out kin to be with. This study helps us understand why animals care about other individuals in their social group. We had clues about their relationships before, but Beth provided proof."

Archie studied the DNA of elephants living in 52 family groups in and around Amboseli National Park. In all, some 1,200 elephants live in Amboseli and the surrounding area, including Mt. Kilimanjaro. Amboseli is the third most-visited park in Kenya and the one most famous for its elephants.

As expected, Archie found that nearly all the elephants living in family groups she tested are closely related. She also found that members of different family core groups within a bond group are also related, albeit less closely. The older females, in particular, shared the same mitochondrial DNA. Archie found that all the elephants in the core groups except three were what geneticists call "first-order" relatives—mothers and their offspring or full siblings—that shared 50 percent of their nuclear DNA and had the same number of repeat gene forms. The exceptions were single, unrelated females living in three of the 52 family groups. Archie thinks they represent survivors of core groups, most of whose members were killed by poachers. Those survivors may have roamed the wild alone until they were accepted into existing family groups.

Fortunately, because of Amboseli's relatively small size (97,000 acres), the tolerant attitude of the local Masai people toward wildlife, and the near-constant presence of scientists and tourists, elephant poaching there is rare. Where poaching and culling do occur, however, it is often the oldest and most experienced elephants that are killed, due to their large tusks or out-front position when defending their group. Such selective killing can destroy the social and kin relationships within elephant family and bond groups. The survivors may lack the knowledge of where food and water can be found, especially during droughts, or the inclination to defend or care for each other. "How will the new groups [formed by survivors] function without genetic ties?" Alberts asks.

Another unanswered question involves single females and which new family groups they join. Although she could not test that question, Archie thinks the answer may depend on how many relatives the single female has in a new group and how closely related they are. Whatever the reason, Archie says, a new unrelated or distantly related female that joins a new family group brings a different set of DNA into the core group, thus diversifying the latter's future gene pool.

By growing up in a social setting in which members of family and bond groups and associations often interact, young elephants learn to recognize their relatives. How they do that is a little unclear, though. Perhaps, Archie says, young elephants learn over time to recognize their relatives by sight, sound, or smell. Maybe they use behavioral clues. Or maybe a little of each. "Elephants have really good memories for social groups and individuals," she states.

Whatever cues elephants use to identify one another, they seem to prefer to hang out with their relatives, Archie found. The adult females in each family group consistently remain closer to one another, more so than they do with more-distantly related elephants or if social interaction were left to chance. Indeed, closely related females spend up to 90 percent of their time with each other.

But Archie says personality differences among individual elephants can lead to behavioral aberrations. She cites one case in which an adult female preferred the company of another, unrelated adult female to that of her own daughter. The mother had once been speared, the geneticist explains, so she tended to act "kind of crazy." In another case, two not closely related females spent more time together than they did with more closely related females.

Archie's genetic studies have shown that when groups break up and re-form during fission and fusion, the adult females in each group remain with their closest relatives—their sisters and daughters. Similarly, core groups fuse when the oldest females in each family group are closely related. "Individual elephants demonstrate a long-term fidelity to their core and bond groups," she says.

Given the close degree of relatedness among elephants in core and bond groups, another question arises: How do elephants avoid inbreeding? Conservationists and wildlife managers are concerned, because inbreeding can result when wildlife populations decline in numbers and become isolated from one another, leaving individuals within isolated populations with few choices for mates. Poaching and culling, as well as human development that cuts off some populations of elephants from others, can create just such situations. Inbreeding can result in a loss of genetic diversity in the population as well as genetic and physiological abnormalities among individual animals.

Karl Ammann/naturepl.com

Archie's work has shown that African savanna elephants avoid choosing their maternal and paternal relatives as mates.

Even without poaching or culling, male elephants typically mate with any female that is receptive at any given time, and females mate with different males over their lifetimes. Thus, the offspring of females may have different fathers and half siblings. Some of an elephant's half siblings may live in different core or bond groups. Given that, how do elephants know which possible mates are relatives and which are not?

Again, Archie is not sure, but has learned through her genetic studies that elephants recognize their relatives: "They avoid their maternal and paternal relatives in selecting mates," she says. Rarely do closely related elephants mate. Of 152 pairs of parent elephants Archie identified through her DNA testing, only five were closely related. Although in the long run the problem of potential inbreeding remains, Archie says, in the short term conservationists and wildlife managers "have one less thing to worry about."

Archie's work is part of a larger effort at the National Zoo to study wildlife genetics in order to better manage and conserve species. Fleischer, for example, is studying the genetics of wild Asian elephants. Other scientists around the world are examining DNA taken from the fossils of mammoths, mastodons, and other extinct elephants to help illuminate the evolution of modern African and Asian elephants.

Meanwhile, in a study similar to Archie's, Jesus Maldonado, a research geneticist at the Zoo and Archie's postdoctoral advisor, is using the dung of wild dogs (*Lycaon pictus*) in South Africa to discern the animals' kinship patterns and how those affect inbreeding and social behavior. And Ben Hirsch, a postdoctoral fellow at the Zoo, has begun looking at the genetics of coatis (*Nasua narica*)—Central and South American animals that are related to raccoons—that also live in female-led social groups.

And that brings us back to elephant dung. Archie says that working with dung is not as bad as one might think, although several times it has almost gotten her into trouble. Once, she left her car to retrieve some fresh dung, and when she returned a tourist who had been watching the same group of elephants from the safety of a van informed Archie that she had been stalked by a lion. "I was so focused on the elephants that I didn't even see the lion," Archie admits. Another time, an elephant charged Archie's car, but stopped short of ramming it. "The elephants watch you as you watch them," she notes.

Dealing with elephant dung was not what Beth Archie had in mind when she started her graduate studies. She intended to be a marine biologist studying sea snails. After a while, though, snails lost their appeal. Her advisor, Susan Alberts, knew Cynthia Moss and the elephant studies at Amboseli, and suggested Archie switch to pachyderms. "They have a lot of personality and personal differences," Archie says. "They're like chimpanzees or humans in having a really complex social organization. You can't guess what is going on with them by their facial expressions or body postures like you can with primates. I'm hooked on elephants." Z

—Freelance writer Jeffrey P. Cohn last wrote about grasslands in the U.S. West in the July/August 2006 issue of ZooGoer.

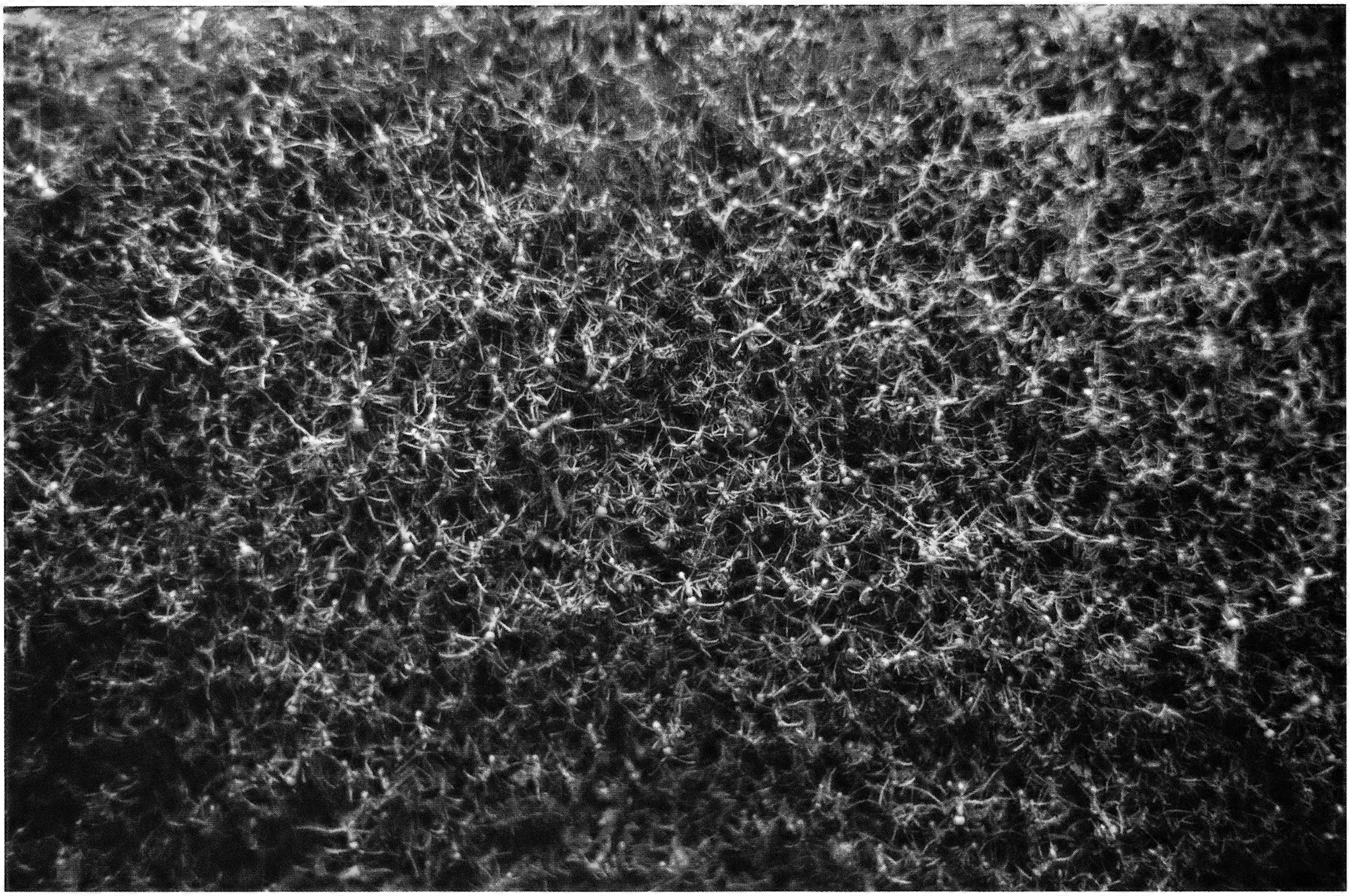
Joe McDonald/Bruce Coleman Inc.

A red-and-yellow barbet (*Trachyphonus erythrocephalus*) stands atop a termite mound, which it may use as its nest. Some bird species obtain shelter or food from the industry of colonial insects.

swarm's way

by Howard Youth

"Whoa! Look over there by the edge of the road," whispered my wife, Marta, her binoculars on the rise. A kiskadee flycatcher, its belly bright as a lemon and its wings rust-orange, flapped from the ground to the trees with a large gray grasshopper dangling from its bill. "Over on that white post," I blurted. A plush-crested jay took center stage, its shaggy head cocked, its blue-ringed yellow eye scanning the ground. In a flash, it hopped down to snap up another grasshopper. A pair of large squirrel cuckoos appeared next, with flowing black-and-white tails, and, on either side of them, four disheveled smooth-billed anis scrabbled, intent on cleaning up at the invertebrate brunch. Once we identified these striking birds, we noticed less flamboyant ones, including pale-breasted and rufous-bellied thrushes and a pair of fawn-breasted tanagers.



Martin Dohrn/naturepl.com

After coursing through the forest floor in search of prey, army ants bring their quarry to their bivouac. The ants' relentless marches flush grasshoppers and other insects from their hiding spots into the open, where hungry birds snatch them up.

We couldn't believe our luck. We knew that a visit to Iguazú National Park at the subtropical border between Argentina and Brazil would give us a good chance of seeing interesting birds. But we never expected to see so many in one place. Then we discovered the reason: ants. Black legions of them coursed through the grass at the forest edge, sending a smorgasbord of larger insects scurrying right into the bills of the birds. We learned that, when birding in or near dark, deceptively quiet rainforest, it's best to listen for the skittering of panicked prey and the chatter of excited birds that mark an army ant swarm.

Feathered creatures have shared the planet with ants and other colonial insects for millions of years. Back in the Cretaceous Period, between 144 and 65 million years ago, when primitive flying birds shared the skies with winged reptiles called pterosaurs, and tyrannosaurs stomped across steamy landscapes, ants, termites, bees, and wasps emerged as a powerful force. Today, they account for an estimated 75 percent of the planet's insect biomass. This summer, while people across the country wield swatters, hoses, and spray cans against them and shout "What good are they?" it's clear that, away from human dwellings, these insects are extremely important within their habitats and to their neighbors. Made of tiny constituents that are together mighty, an insect colony can be a nuisance or danger, or for birds, an essential resource to be followed for the great opportunities it offers.

Lean, Seen Swarming Machines

"Ants are everywhere, but only occasionally noticed," wrote entomologists E.O. Wilson and Bert Hölldobler in their 1990 classic *The Ants*. "They run much of the terrestrial world as the premier soil turners, channelers of energy, dominatrices of the insect fauna—yet receive only passing mention in textbooks on ecology." But step off a forest trail in the tropics, and you can't help but notice these omnipresent, industrious insects. In Amazonia's *terra firme* forests, ants and termites alone account for an estimated one-third of the entire animal biomass. They are likely just as abundant in many other habitats across the globe, according to Wilson and Hölldobler.

The most feared and celebrated are the army ants. According to Wilson and Hölldobler, about 300 of the world's approximately 9,000 ant species can be called "army ants" for their frequent migrations and group-hunting habits. Most army ants live in the tropics and subtropics, including southern Mexico, Central and South America, Australia, Africa, and Asia. But a few species reach as far north as Iowa and Virginia.

Eciton burchelli is the best-known army ant in Central and South America. A colony of these large, long-legged ants ranging through the forest does not have a fixed address. Wherever the colony settles for the night, usually at a sheltered site on the forest floor, *is* its home. Several castes of ants exist within the colony, including hundreds of thousands of workers. At night, workers link

legs and form layer upon layer of ant chain, protecting one elongated queen and many immature ants at its center. Several virgin queens and males—the raw materials of future colonies—are also in attendance for a short time each year. All told, the massed and resting colony, a ball called a bivouac, can span three feet in diameter.

As morning light filters to the forest floor, the ball unravels and the ants head out on their daily hunt. Waves of workers push forward, laying down chemical markers, or scent trails, from the tips of their orange abdomens to guide compatriots that follow and soon take the lead. An *E. burchelli* swarm rolls across the forest floor like a line of miniature bulldozers, plowing over, killing, and breaking apart invertebrates such as tarantulas, scorpions, roaches, beetles, grasshoppers, and ants of other species, as well as small snakes, lizards, frogs, and other small creatures that don't make it out of the way. Bits of prey are transported back to the colony's current bivouac site, where the queen and young are tended by workers. Meanwhile, larger, bulky-headed soldiers cruise the shoulders of the ant highway, defending workers as needed.


Martin Dohrn/naturepl.com

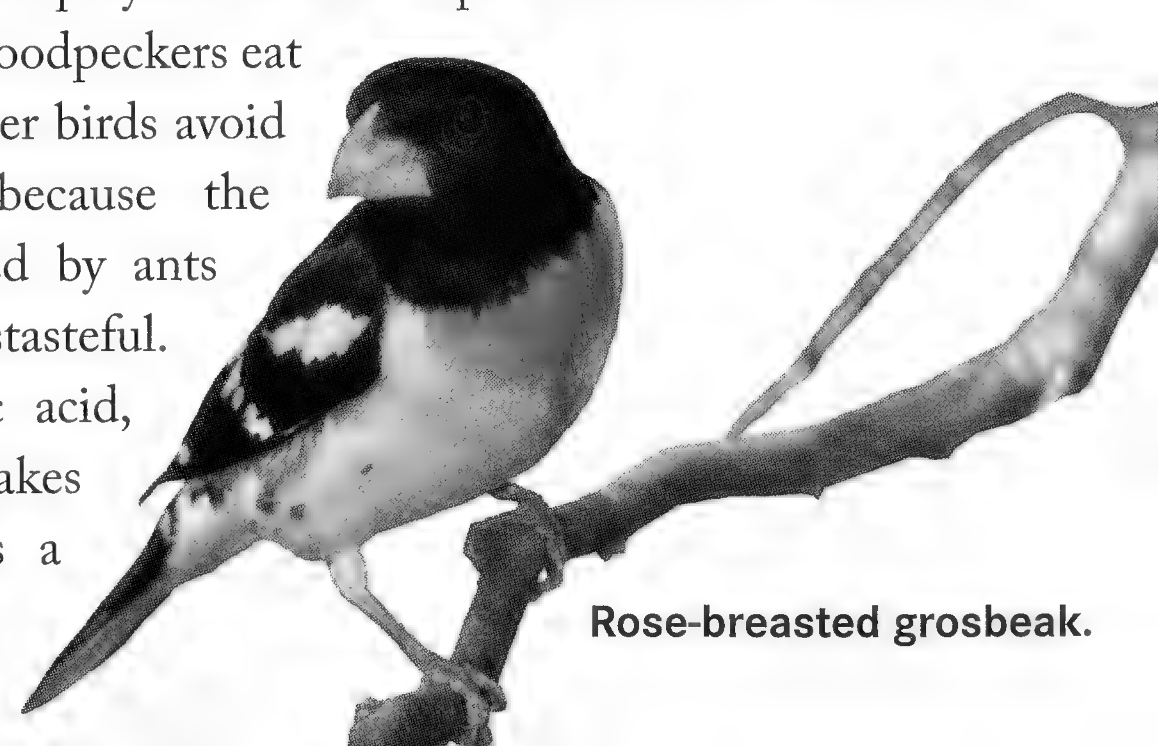
African driver ant soldiers have no eyes, and use their large jaws defend the colony from intruders.

Army ants are top predators of many forest floor invertebrates, but pose little threat to most mammals and birds. The dean of Neotropical ornithology, Alexander F. Skutch, chronicled Central American bird behavior for more than 70 years, until his death in 2004. Many times he watched army ants course over and around incubating birds, but he wrote that "I have never known them to harm a bird of any kind." Skutch considered army ants far less of a threat to birds' eggs and broods than other types, such as fire ants (*Solenopsis* spp.). Apparently, movement spurs army ants to attack, and incubating birds and some large insects escape notice by sitting stock still.

So, for birds, army ant swarms are not usually a cause for panic, but instead offer a great chance to snap up a wave of fine living foods. In Amazonia, up to 50 bird species may be represented in a single army ant-following flock. These include obligate species, which always attend swarms and appear to be dependent upon them, as well as opportunists that make the most of it when they happen upon a swarm. Swainson's thrushes (*Catharus ustulatus*), and rose-breasted grosbeaks (*Pheucticus ludovicianus*) are among the Neotropical migrants—birds that nest in North America but winter in the tropics—that opportunistically join frenzied resident antbirds, antthrushes, antpittas, antshrikes, tanagers, and woodcreepers at army ant swarms. Resident birds, however, often chase these migratory birds away, leaving them to snatch whatever scraps they can at the edge of the swarm. Larger Central and South American birds known to follow ant swarms include motmots, some toucans, and the 19-inch-long rufous-vented ground-cuckoo (*Neomorphus geoffroyi*). As they follow army ants, these birds attract butterflies that feed on their nutrient-rich droppings.

Hunting and bivouacking habits vary among army ant species and genera. Driver ants (*Dorylus* spp.) are the most infamous army ants of Africa. Their colonies tend to contain far more workers than those of *E. burchelli*, and they often cluster below ground to excavate their nests. Wilson and Hölldobler wrote that Africa's "driver ants are not really the terror of the jungle as popularly conceived. Although the colony is an 'animal' weighing in excess of 20 kilograms [44 pounds] and possessing on the order of 20 million mouths, its raiders move over the ground at the rate of only a meter [just over three feet] every three minutes. It is possible to watch the whole process at close range while seated comfortably in a camp chair. . . ."

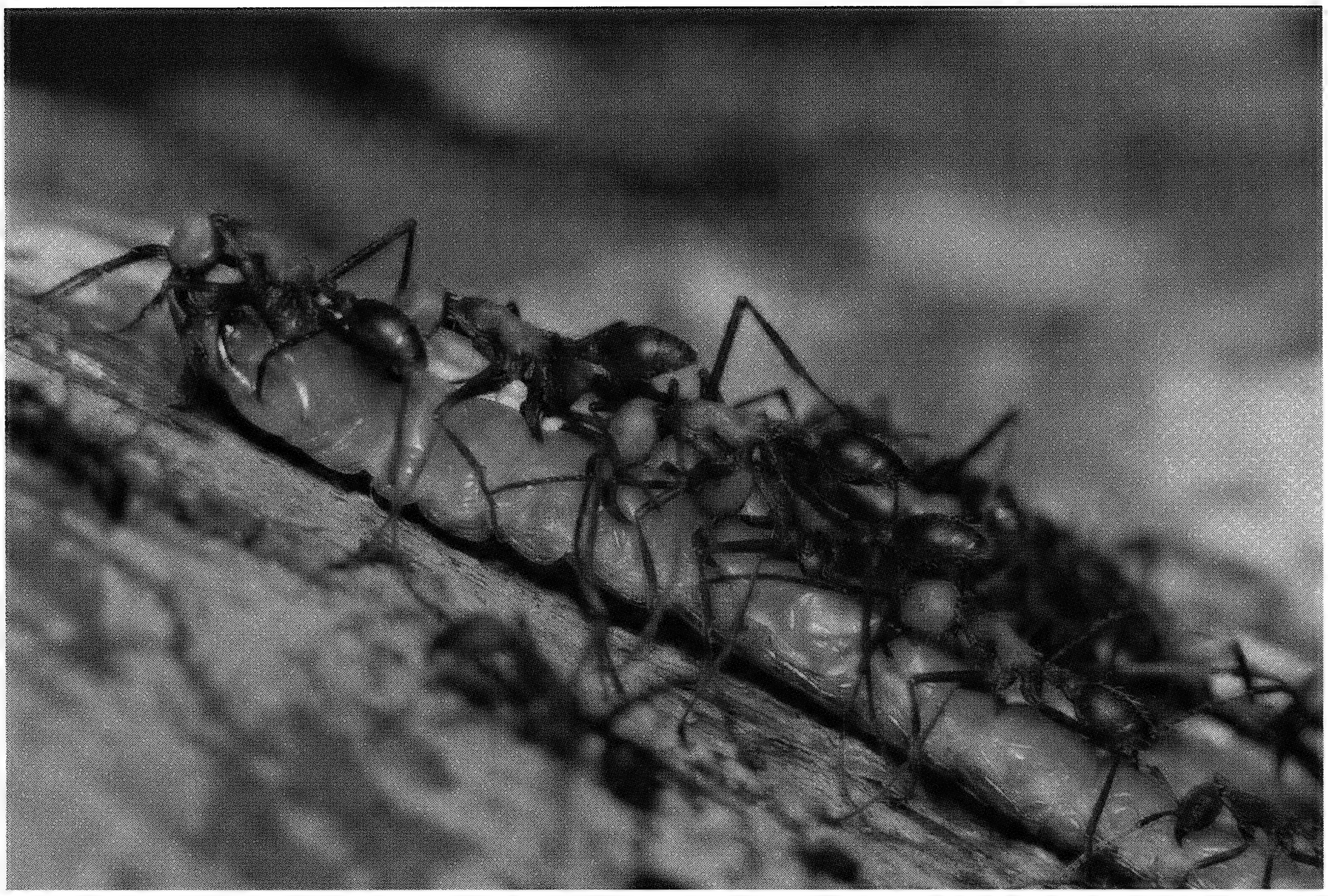
As driver ant columns move across African landscapes, they resemble thick black ropes draped over the ground. In sub-Saharan undergrowth, a sinuous colony of millions may, among other creatures, attract opportunistic songbirds such as red-tailed antthrushes (*Neocossyphus rufus*) and white-starred robins (*Pogonocichla stellata*). The antthrushes feed on the ants and the insects they flush, while the robins favor just the fleeing insects. In central African forest, the chocolate-backed kingfisher (*Halcyon badia*), which normally sits high in the trees looking for prey, perches low when following driver ant columns to gobble up some ants along with the grasshoppers, beetles, mantises, crickets, and other prey the ants kick up. Like the antthrush and kingfisher, many woodpeckers eat ants. But most other birds avoid them, probably because the formic acid exuded by ants renders them distasteful. That same formic acid, however, likely makes them desirable as a


Rolf Nussbaumer/naturepl.com

Rose-breasted grosbeak.

preening accoutrement. (See sidebar, "Ants, a Quick Picker-upper.")

Many aspects of army ant ecology remain unstudied, but a consensus is emerging among scientists that the ants are important to a host of animals that would not flourish without them. "Their triple importance as predators, prey, and hosts for parasites and commensalists strongly suggests swarm-raiding army ants have keystone functions in tropical forest communities," wrote biologists Caspar Schoning, Wanja Kinuthia, and Jacobus J. Boomsma in the *Journal of East African Natural History* in 2006. But at least some of these formidable insects have an Achilles' heel. In 2000, biologists Dina L. Roberts, Robert J. Cooper, and Lisa J. Petit, from the University of Georgia and the Zoo's Smithsonian Migratory Bird Center, reported in the journal *Conservation Biology* that two widespread Neotropical army ants, *E. burchelli* and *Labidus praedator*, thrive in Panamanian natural forest and shade-coffee plantations but are absent in the country's exposed sun-coffee plantations. Among the likely reasons: The ants, which hunt in thick leaf litter and, in the case of *E. burchelli*, seek woody materials such as fallen logs for bivouac sites, can't find enough of this matter in the warmer, drier sun-coffee plantations.


Martin Dohrn/naturepl.com

Army ants drag a centipede back to the bivouac for consumption.

In another study published in *Ecological Applications* in 2000, Roberts, Cooper, and Petit tallied ant-following bird species in Panamanian mid-elevation forest, adjacent shade-coffee plantations, isolated shade plantations, and sun-coffee plantations. All habitats except sun-coffee plantations supported large numbers of ant swarms, and the team tallied a total of 126 ant-attending bird species. But forest and shade-coffee plantations *adjacent* to forest held the most intact bird assemblages when compared with isolated shade-coffee patches. The authors hypothesized that "army ants may...be a mechanism for bringing forest birds into shade coffee, but only to a point."

Ants, a Quick Picker-upper


John Downer/naturepl.com

An anting rook with wings spread.

More than 200 bird species grab ants and rub them over their wing and tail feathers, or sit down amid a group of ants and let the little creatures crawl all over them. Although ornithologists have observed this odd behavior, called "anting," for more than 65 years, few agree on exactly why it occurs, but they have several hypotheses. The formic acid exuded by ants may help birds repel lice and other ectoparasites, or protect the birds from infection. Maybe the acid tingles and soothes skin irritation when birds molt. Or, anting might remove unpalatable substances, such as formic acid, from ants so the birds can eat them.

Most anting episodes have been observed in songbirds from temperate areas, including jays, crows, dippers, towhees, sparrows, orioles, tanagers, grackles, and robins. But the late Neotropical ornithologist Alexander F. Skutch and others have caught tropical birds in the act, including woodcreepers, saltators, seedeaters, and flycatchers. Temperate birds typically ant on or near the ground, while tropical birds usually ant in bushes and trees.

Ants are not the only species used for anting: Birds also rub millipedes, flowers, mothballs, and caterpillars against their wing and tail feathers and skin. Following his description in the *Wilson Bulletin* in 1998 of a Costa Rican three-striped warbler (*Basileuterus tristriatus*) that repeatedly rubbed a caterpillar over its wings and afterward vigorously wiped its bill on a twig, biologist Dan Wenny, then at the University of Florida, wrote that "anting remains one of the unexplained puzzles of ornithology. The available information is dominated by anecdotal observations (such as this one)." Wenny added that "the few experiments thus far have reached conflicting conclusions, perhaps because each has tested only one of the hypothesized functions."

—Howard Youth

Disappearance of shaded forest habitat, and the subsequent disappearance of army ants, does not bode well for birds adapted to finding food flushed by ants. In the Neotropics, the most vulnerable are the obligate ant followers, such as the white-plumed antbird (*Pithys albifrons*), a fixture at many Amazonian ant swarms, and, across most of the range of *E. burchelli* from Mexico to Brazil's southern border, the ruddy woodcreeper (*Dendrocincla homochroa*) and gray-headed tanager (*Eucometis penicillata*), among others.

The effects of forest loss on army ants appear to be very different in East Africa, at least for driver ants. In their 2006 study, Schoning, Kinuthia, and Boomsma surveyed Kenyan forest plots of varied sizes as well as adjacent open habitats, and concluded that populations of driver ants did not seem to suffer from forest fragmentation: They seem to do just as well in farmland and other sunny, disturbed landscapes as they do in shady forest.

Shelter in the Swarm

Other colonial insects attract birds and ants. Among them are termites, which are eaten by ants, birds, mammals, and reptiles. There's quite a menu from which to choose: Worldwide, there are more than 2,700 termite species. Most of these feed on dead wood and other plant matter, and fewer than 200 colonize houses.

Craggy termite nests, or termitaria, are familiar adornments to many tropical landscapes. Termites may nest below ground, on the ground, or in trees, depending upon their species and habitat. Their termitaria are often large and riddled with chambers that regulate the temperatures within, keeping the colony from baking in the tropical heat that blazes just outside. Inside, the cool, dark interior shelters a long-lived queen (she may live for several decades) that lays all the eggs, while sterile workers labor to maintain and build the nest and its chambers.

Just as prairie dog colonies shelter snakes and ferrets, termitaria attract their fair share of freeloaders. Birds in the colorful trogon family, for example, favor arboreal termitaria as sites for their tunnel nests. All trogons are cavity-nesters, and almost a third of New World species will sometimes or often excavate their nests in arboreal termitaria. At least one, the white-tailed trogon (*Trogon viridis*), nests virtually nowhere else.

A female blue-crowned trogon (*Trogon curucui*) pauses at the entrance to her nest in a termitary.

Peter Oxford/naturepl.com

In a study of Peruvian termitary-nesting birds published in the journal *The Condor* in 2000, biologist Donald J. Brightsmith reported that trogons and some other birds seem to prefer to nest in termitaria also inhabited by aggressive, biting ants (*Dolichoderus* spp.). These ants may unwittingly protect the birds' nests by discouraging predators or by providing "olfactory camouflage" with their strong scent that masks nest odors, and thus keeps the birds safe from night-prowling rodents and marsupials. There is anecdotal evidence that the ants also help tidy the birds' nests, ridding them of feces and ectoparasites.

Taking advantage of their termite hosts' remodeling skills, a trogon pair take turns gouging out their nest chamber. They typically choose active termitaria, which are sturdy enough to withstand excavation. Eating termites as they work, the trogons keep the cavity and chambers open while the insects busily repair interior walls. When the trogons abandon their nest after their chicks have fledged, the termites reclaim what's rightfully theirs, patching up all the walls and resealing the excavated cavity.

The violaceous trogon (*T. violaceus*), which skulks at forest edges from Mexico to Brazil, ventures where few others will. In his field guide to Costa Rican birds, Skutch wrote that this trogon nests not only in termitaria but also "in a chamber carved in a high gray, top-shaped arboreal nest of *Parachartergus* wasps, less often in a blackish, stalactite-like, arboreal nest of *Azteca* ants, in a decaying trunk, or in a dense mass of roots of a large fern or other epiphyte." The violaceous trogon is the only New World bird known to nest in ant and wasp nests. (In Africa and Asia, a few barbets and woodpeckers nest in arboreal ant nests.) Before taking up residence in a wasp nest, a trogon pair ensure that their young won't be stung: They systematically kill all of the resident wasps.

While they may avoid wasp and ant nests, birds other than trogons nest in termitaria. Dagger-billed Neotropical aerialists called jacamars burrow into arboreal termitaria with their bills and kick debris away with their small feet. Chunky, thick-billed puffbirds also chip away at and nest in termitaria, as do about two dozen parrot species—roughly ten percent of the world's 250 species.

Not all termitaria are created equal in the eyes of parrots and some other birds. A natural

Nigel Dennis

A greater honeyguide sits on honeycomb in KwaZulu-Natal, South Africa. These birds sometimes lead people to beehives, which they can't open themselves.

partitioning seems to occur, based on what each species considers the optimal nest site. In the Peruvian Amazon, for example, Brightsmith found no shortage of termitaria but noted that black-tailed trogons (*T. melanurus*) used larger termite nests situated lower in trees than those used by cobalt-winged and Tui parakeets (*Brotogeris cyanoptera* and *B. sanctithomae*). While the parakeets chose similar termitaria, the cobalt-winged parakeets nested in mature forest and the Tui parakeets nested in edge and young forests.

Towering ground termitaria also provide a variety of birds with food, look-out and territorial perches, and nesting opportunities. In Africa, for example, barbets in the genus *Trachyphonus* burrow into earth banks or terrestrial termitaria, tunneling up to 16 inches into a mound. In South America, even tree-nesting toco toucans (*Ramphastos toco*) sometimes occupy burrows previously chiseled into terrestrial termitaria by nesting woodpeckers called campo flickers (*Colaptes campestris*).

Combing the Forests for Honey

In Africa and a few parts of Asia, frumpy-looking birds called honeyguides frequent beehives to feed on the bees as well as their wax, larvae, and eggs. Most of the world's 17 honeyguide species consume beeswax, but none is large or strong enough to tear open a hive. For that, they rely upon mammals such as humans and African honey badgers (*Mellivora capensis*) that seek the honey inside the hives.

Most honeyguides follow these hive-opening mammals, but the greater honeyguide (*Indicator indicator*) actually takes the lead, actively drawing people to wild beehives. The cardinal-sized bird's persistent trills, which sound like a shaking match box, provide the first clue that honey is ahead. Then the bird takes off and shows the way to the hive with a series of short, undulating flights, its bold white outer tail feathers flashing. When it reaches its target, the honeyguide quiets down and perches nearby, then waits for the hive to be found and opened, its waxy treasure exposed, and its stinging residents evicted. Guiding is likely a learned behavior: In suburbs, such as those around Nairobi, honeyguides no longer attempt to guide, apparently because links between mammalian hunters, birds, and hives have broken down.

Much remains to be learned about the intriguing ties between invertebrates and birds. Their complex interactions provide fodder for future scientific study and cherished memories for nature lovers lucky enough to glimpse them in action. It's been a decade since Marta and I watched the Iguazú bird feeding frenzy, but those few sublime moments forever cemented in our minds the importance of the links between beings avian and invertebrate. Z

—Contributing editor Howard Youth last wrote about lekking prairie grouse in the March/April 2007 issue of ZooGoer.

Evolution Revolution

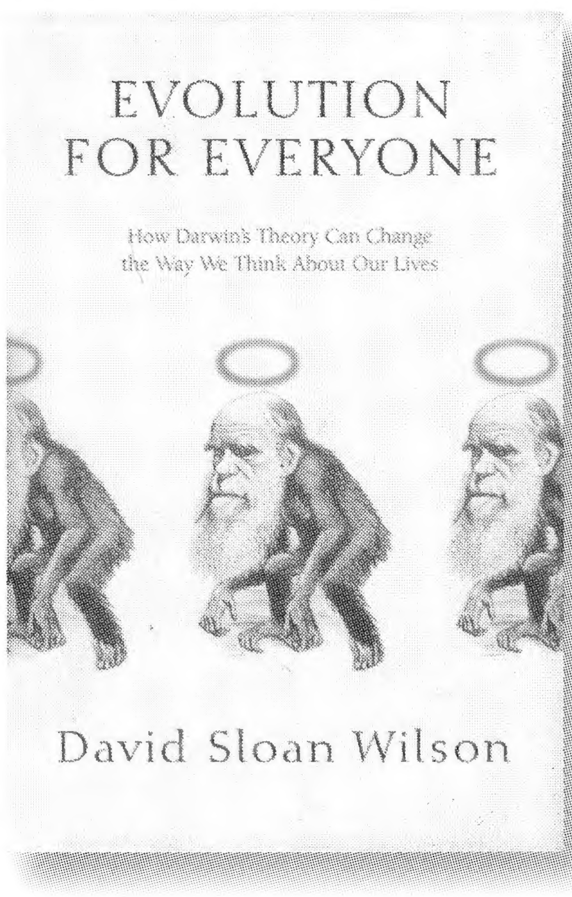
Evolution for Everyone:
How Darwin's Theory Can Change the Way We Think About Our Lives
David Sloan Wilson. 2007. Delacorte Press, New York. 390 pp., hardbound. $24.

Of the fewer than half of adult Americans who accept the fact that we evolved from an earlier species, most don't give the matter much more thought. That our ancestors and our closest living relatives are hairy apes, cool as that might be, doesn't help us get through another dreadful day at the office. But evolution is about lots more than the ancient branches of our family tree, as the renowned evolutionary biologist Theodosius Dobzhansky wrote in a 1973 essay called, "Nothing in Biology Makes Sense Except in the Light of Evolution."

In *Evolution for Everyone*, Binghamton University evolutionist David Sloan Wilson focuses that light on human biology to illuminate how thinking as an evolutionist will lead to a better understanding not only of our bodies but our behavior and even the basis of morality. In essence, Wilson argues that the only way to make sense of human and all life—to answer the why questions—is in the framework of evolutionary theory. Moreover, this understanding can be profoundly useful for forging a better life. And anyone—everyone!—can do it because the theory of evolution by natural selection is conceptually so simple.

Sloan likens it to a recipe with three ingredients. Start with variation among individuals in any attribute or behavior. Add the survival and reproductive consequences—the costs and benefits—of that variation: being smaller or braver or whatever leads to longer lifespan and more babies than being bigger or fearful in a particular environment. Then throw in "a sort of yeast that makes the recipe come to life"—heredity (the fact that children tend to be like their parents)—and, over time, the smaller or braver individuals will predominate due to their superior adaptations to the environment.

Following the recipe, it's easy to conjure up hypotheses about why animals, including humans, are what they are and do what they do. (Although it's usually not easy to test them—Wilson does a great job describing the "roll-up-your-sleeves" work that scientists must to do to document facts "the way a brick factory produces bricks." In addition to reading this book for his witty, clear elucidation of evolution theory, read it for the insight Wilson offers into how scientists work and think, and, through detailing his personal experiences, how they navigate through the contemporary academic habitat.)



Take just one example of the many Wilson offers to support the utility of evolutionary thinking to human well-being. Infanticide is not uncommon in the animal world and on the surface looks like a bad idea. Thinking like an evolutionist, however, makes this seemingly aberrant behavior explicable.

Under what conditions might infanticide be advantageous, defined as increasing the killer's reproductive success, and thus evolve? Lack of resources, food for instance, might favor eliminating some of your own offspring so the others survive. Further, if some of those offspring are of poorer quality than others (smaller, weaker, say), then it would be advantageous to eliminate those rather than their bigger, stronger siblings.

Another situation that favors the evolution of infanticide is when the offspring aren't your own. It may benefit a male, for instance, to kill the young of another male if doing so makes room for his own. Wilson's own experiments with infanticidal burying beetles clearly support two of these three hypotheses and, he suspects, will support the third when he does the tests. Indeed, the infanticidal behavior in many species, including lions and langurs, is explained by one or all of these three hypotheses.

And what of our own species? One team of scientists has combed homicide records and other data sources to find that scarce resources and offspring quality explain variation in the occurrence of infanticide in both modern and traditional human cultures, too. Further, and most surprising, a human infant is 20 to 100 times more likely to be killed by a stepparent than a natural parent! Evolutionary thinking identified genetic relatedness as an important risk factor for infanticide and its lesser form, child abuse, a factor not previously considered by criminologists and social scientists. Knowing this is the first essential step toward minimizing these crimes.

Among the many other subjects that Wilson's evolutionist thinking sheds new light on are why we get sick, the current obesity crisis, why we dance and enjoy music, and even why we are religious, which Wilson repeatedly points out is not at odds with our being evolutionists. Wilson also weaves into his story a host of examples from the animal world, reminding us that the differences between human and other animals are products of evolution as well.

Evolution for Everyone is as fascinating as it is readable. This is the rare work of scientific writing that all can peruse for pleasure and intellectual profit. You could even take it to the beach.

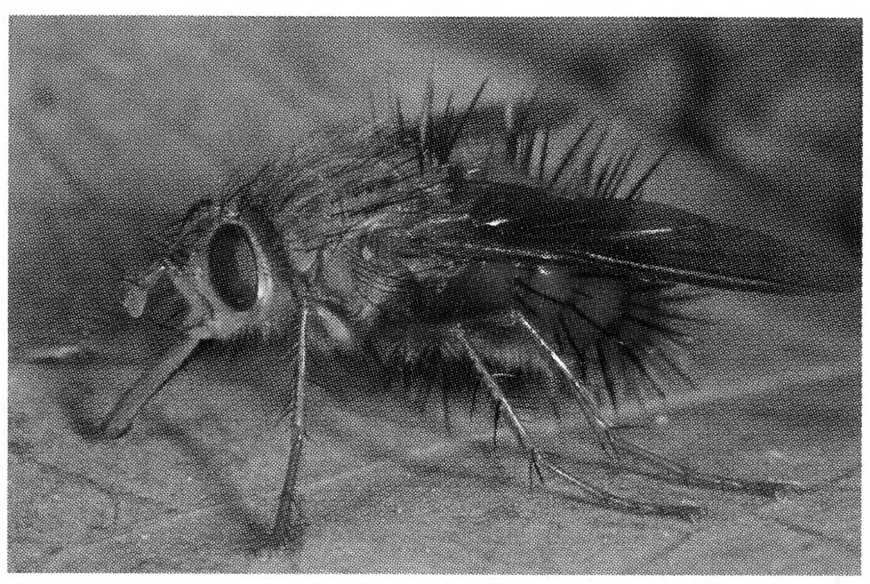
—*Susan Lumpkin*

by Shannon Lyons

Give Me Shelter

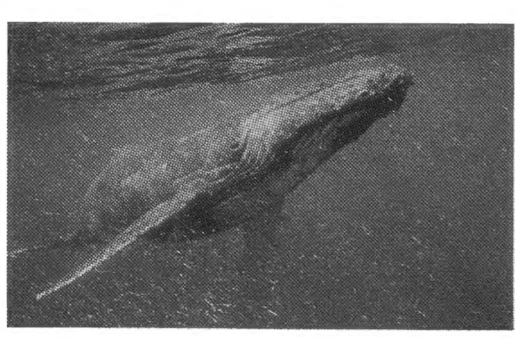
Like men flexing their biceps on the beach to attract the ladies, male fiddler crabs (*Uca terpsichores*) wave their one large claw to get the attention of prospective mates. But they need more than a seductive gesture to seal the deal with choosy females. The most appealing males also shield their burrows from predators with a mound of mud, or a "hood," according to a study by scientists from Seoul National University in Korea and the Smithsonian Tropical Research Institute in Panama. Female fiddlers risk predation when they scuttle over open sand to inspect males and their burrows. The scientists found that in areas with greater concentrations of predatory great-tailed grackles (*Quiscalus mexicanus*), females were more attracted to males with burrow hoods and were more selective—they visited up to 100 burrows before picking a mate—than in areas with fewer grackles. The study, which was published in the May 2007 issue of the journal *PLoS ONE*, demonstrates that males that help females avoid predation have a reproductive edge over males that don't.

What's in a Name?

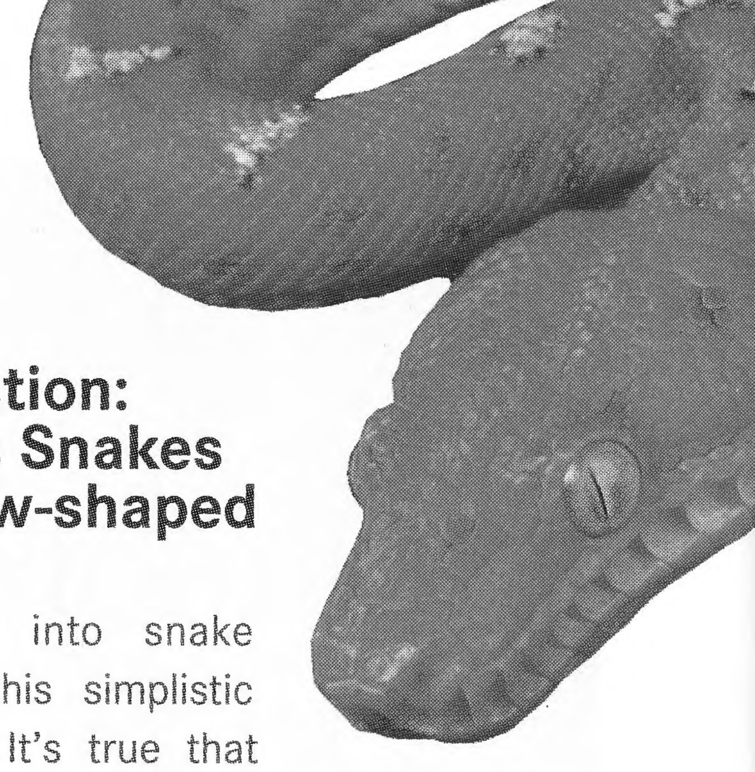


If creepy-crawlies bug you this summer, distract yourself with some insect etymology. In the early 17th century, insects got their name from the Latin word *insecare*, meaning "cut into," because they have segmented bodies. "Bug" traces back to the 14th-century Middle English word *bugge*, meaning "hobgoblin"; in the 15th century it was incorporated into the noun "bugbear," meaning a continual source of irritation or dread.

Most of us do dread swarms of biting gnats, mosquitoes, and insects that sting. "Swarm" comes from the Old English word *swearm*, probably by way of the Latin word *susurrus*, meaning "hum" or "buzz," both familiar sounds at beehives. "Gnat" comes from the Old English word *gnætt* and the closely related *gnagan*, to gnaw; these annoying little flies of the order Diptera may gnaw on your skin, and their incessant presence will certainly gnaw on your nerves. "Mosquito" was coined by the Spanish, and adopted into English in the 16th century. Literally, it means "little fly": The prefix comes from the Spanish word for fly, *mosca*, and *-ito* is a diminutive suffix. And "sting" may have evolved from the Greek words *stochos*, meaning "aim," and *stachys*, meaning "spike of grain," perhaps because an insect's stinger resembles one.



Humpback whales (*Megaptera novaeangliae*) undertake the farthest recorded migration of any mammal. Some travel more than 5,000 miles between their feeding and breeding areas.



Fact or Fiction: Venomous Snakes Have Arrow-shaped Heads

Don't venture into snake territory with this simplistic myth in mind. It's true that venomous snakes such as copperheads, cottonmouths, rattlesnakes, and most other members of the viper family have triangular heads that are much wider than their necks. But so do nonvenomous snakes such as pythons and boas, which kill prey with their strong constricting muscles. Conversely, some of the world's deadliest venomous snakes, including coral snakes and mambas, have small, round heads. The most reliable way to determine whether a snake is lethal or harmless is to consult a field guide.

Why Don't Dogs and Cats Sweat?

Humans and horses are among the few mammals that regulate their body temperature by sweating. Eccrine sweat glands all over their bodies produce perspiration that cools them down as it evaporates from their skin. Dogs and cats can't sweat because they have only a few eccrine glands, in the pads of their paws. They chill out by panting through their noses or mouths to increase the flow of air, and thus the evaporation of moisture, in their upper respiratory tracts. This in turn cools blood that is carried throughout their bodies. Pigs don't sweat either; instead, they wallow in mud or water to mitigate the heat. They only have eccrine glands on their snouts and near their feet, so it's impossible to "sweat like a pig."

In Season

If you're vacationing near a mid- or northern Atlantic beach in late July or August, keep an eye out for shorebirds on their annual southward migration. Shorebirds that breed in arctic regions sometimes stop on Atlantic shores and wetlands this time of year to rest and refuel en route to their wintering grounds in the Caribbean, Mexico, and Central and South America. Look for plovers, turnstones, and sandpipers, as well as red knots (*Calidris canutus rufa*), which breed on arctic tundra then migrate more than 9,000 miles to spend the winter on the southern tip of South America.

Fiddler crab: John Christy/STRI. Beelike tachnid fly (*Bombyliopsis abrupta*): Edward L. Snow/Bruce Coleman Inc. Humpback whale: Richard Lang. Emerald tree boa (*Corallus caninus*): John Bell/Bruce Coleman Inc. Sanderling (*Calidris alba*): Larry Ditto Nature Photography/Bruce Coleman Inc.

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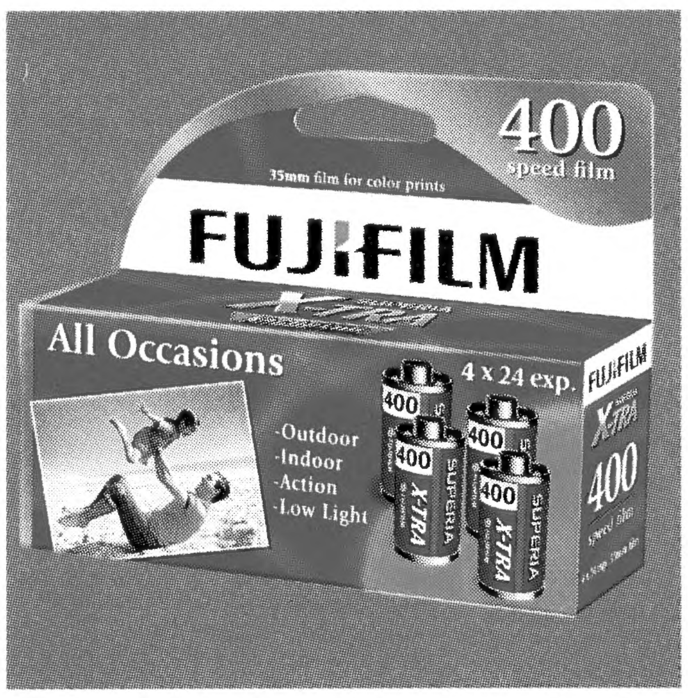

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